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AERONAUTICAL ENGINEERING REVIEW

APRIL 1952

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AERONAUTICAL ENGINEERING REVIEW

Cover—Thin coatings of ice covering a group of McDonnell F2H-2 Banshees glisten in the late afternoon sun. This photograph, showing the Banshees tied down securely on the ramp at the McDonnell Aircraft Corporation plant in St. Louis, was taken after a winter's ice storm.

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I. A. S. News

A Record of People and Events of Interest to Institute Members

I.A.S. Group Visits Eglin A.F.B.

AT THE INVITATION of Air Force Secretary Thomas K. Finletter, 80 security-cleared I.A.S. Corporate Member representatives made a flying trip to Florida, February 3–5, to inspect the facilities and activities at Eglin Field. This giant proving grounds, under the command of Major Gen. B. L. Boatner, U.S.A.F., and staffed by some of the Air Force's most competent officers and specialists, serves as the principle test center for all production items used by the Air Force. Whether they be flying boats, airplanes, armament, or arctic huts, Eglin has the specialists and the facilities to test them under almost any simulated combat, operational, or climatic conditions.

Exactly what, when, and how things are being tested at any given time is naturally classified information. It is no breach of security, however, to state that the Institute's people were greatly impressed by what they saw and by the job being done at this important Base.

Transportation to Eglin was arranged and carried out by Special Air Missions. Members of the I.A.S. party were picked up in New York and Washington on Sunday, the 3rd, flown to Eglin, and back on the 5th, in a routine and flawless operation typical of this Air Force group.

A reception on Sunday evening and a reception and dinner on Monday night at the Officers' Club highlighted the social aspects of the trip. Guests were billeted in the various V.O.Q.'s on the Base during the two-night stay.

Monday was devoted to the "business at hand," with a briefing and indoctrination session in the morning, and an inspection of the climatic hangar, test labs, and flight line during the afternoon.

Although this was the first Institute-sponsored group-visit to Eglin, it served to point-up even further the value of these periodic field trips to the various military installations. The personal contacts and frank discussions between responsible military personnel and top engineers and executives of industry, as represented by the I.A.S., bring about a quicker solution to the problems involved in the nation's defense. In this respect, the trip to Eglin was well worth while.

W.A.S.

I.A.S. on P.A.C.

President's Airport Commission Is Composed of Two I.A.S. Past-Presidents and Honorary Fellows and One I.A.S. Honorary Member; I.A.S. Director Is Executive Director.

THE PRESIDENT OF THE UNITED STATES, Harry S. Truman, appointed the President's Airport Commission by directive of February 20. This temporary commission is making "a national study of airport facilities, both civil and military, their location as to convenience and utility and the problems they may present as to nuisance and possible danger" to adjacent communities. Also under consideration are the "future developments of aviation to determine whether or not the present airports meet not only today's requirements but also anticipate those which will result from technological improvements, taking into consideration the impact of modern airports on city planning."

Lieutenant General James H. Doolittle, U.S.A.F.R., I.A.S. Past-President and Honorary Fellow, who is a Vice-President and Director of Shell Oil Company, was designated Chairman of the Airport Commission. Serving with General Doolittle on this investigatory group are Dr. Jerome C. Hunsaker, I.A.S. Past-President and Honorary Fellow, Head of Massachusetts Institute of Technology's Department of Aeronautical Engineering, and Charles F. Horne, Administrator, Civil Aeronautics Administration, an Honorary Member of the Institute. General Doolittle and Dr. Hunsaker are I.A.S. Founder Members.

I.A.S. Director, S. Paul Johnston, F.I.A.S., was designated as Executive Director. In this capacity, he directs the commission's working staff. With the permission of the I.A.S. Council, Mr. Johnston is temporarily spending part of his time in Washington on behalf of the commission. It will be recalled that he performed a similar function for the Air Policy Commission that was established in the summer of 1947 under Thomas K. Finletter to assist the President of the United States in the formulation of a National policy for the development of postwar aviation.

In the letter to General Doolittle which appointed him to the chairmanship of the commission, President Truman outlined the objectives and considerations of the commission. Referring to the major considerations, President Truman wrote: "On one hand, provision must be made for the safety, welfare and peace of mind of the people living in close proximity to airports. On the other hand, recognition must be given both to the requirements of national defense and to the importance of a progressive and efficient aviation industry in our national economy."

In addition to these "general considerations," President Truman expressed the wish that the committee take the following matters into account: (1) the Federal, State, and local investment in existing civil and military airports and the factors affecting the utility of airports to adjacent communities; (2) actions by Federal, State, and local authorities to lessen the hazards surrounding existing civil and military airports; (3) assignment of newly activated military units to existing airports, with particular regard for potential hazards to the communities involved; (4) site selection for new civil and military airports and the factors affecting relocation of existing airports; (5) joint civil and military use of existing or new airports; and (6) legislation and appropriations necessary to carry out appropriate policy.

Staff advisers working with the Airport Commission are: John W. Crowley, Jr., F.I.A.S., Associate Director for Research, N.A.C.A.; Capt. W. P. Cogswell, U.S.N.; Col. Ross Milton, U.S.A.F.; Phillip A. Hahn, C.A.A.'s Office of Airports; and A. D'Arcy Harvey, C.A.A.'s Economic Staff.

The life of the President's Airport Commission will necessarily be of short duration, for President Truman has requested that "because of the urgency of the problem," final recommendations be submitted to him within 90 days. General Doolittle, however, hopes to complete the commission's comprehensive study in less than the allotted time. In the matter of final recommendations, General Doolittle stated that the commission would take into account the cost of any program it might recommend as well as its effect on the nation's air defense potential.

Shown with President Harry S. Truman at the time the President's Airport Commission was established are: Lt. Gen. James H. Doolittle, U.S.A.F.R., seated with the President; Charles F. Horne, standing immediately behind General Doolittle; and S. Paul Johnston, standing on the left. Dr. Jerome C. Hunsaker was unable to attend the formal ceremony.

N.A.C.A. Technical Committees Named

The appointment of approximately 400 aeronautical leaders to membership on N.A.C.A.'s 26 technical committees and subcommittees for the current calendar year was recently announced by Dr. J. C. Hunsaker, H.F.I.A.S., N.A.C.A. Chairman. The appointees, who serve in a personal and professional capacity without compensation, are primarily responsible for providing "material assistance" in the formulation of N.A.C.A. research programs.

Chairmen of N.A.C.A.'s five major technical committees are: **Aerodynamics,** Dr. Theodore P. Wright, H.F.I.A.S., Vice-President for Research, Cornell University; **Power Plants for Aircraft,** Ronald M. Hazen, F.I.A.S., Director of Engineering, Allison Division, General Motors Corporation; **Aircraft Construction,** Dr. Arthur E. Raymond, H.F.I.A.S., Vice-President, Engineering, Douglas Aircraft Company, Inc.; **Operating Problems,** William Littlewood, F.I.A.S., Vice-President, Engineering, American Airlines System; and **Industry Consulting Committee,** William M. Allen, President, Boeing Airplane Company.

The chairmen of the 21 subcommittees are: **Fluid Mechanics,** Dr. Clark B. Millikan, H.F.I.A.S., Director, Daniel Guggenheim Aeronautical Laboratory, California Institute of Technology; **High-Speed Aerodynamics,** Dr. Allen E. Puckett, M.I.A.S., Head, Missile Aerodynamics Section, Department of Electronics and Guided Missiles, Hughes Aircraft Company; **Stability and Control,** Capt. Walter S. Diehl, U.S.N. (Ret.), H.F.I.A.S., Washington, D.C.; **Internal Flow,** Philip A. Colman, A.F.I.A.S., Chief Aerodynamics Engineer, Lockheed Aircraft Corporation; **Propellers for Aircraft,** Thomas B. Rhines, M.I.A.S., Assistant Chief Engineer, Hamilton Standard Division, United Aircraft Corporation; **Seaplanes,** Grover Loening, I.A.S. Fellow and Benefactor, Washington, D.C.; **Helicopters,** Bartram Kelley, M.I.A.S., Chief Engineer, Helicopter Division, Bell Aircraft Corporation; **Aircraft Fuels,** Dr. J. Bennett Hill, Director, Chemical and Engineering Division, Research and Development Department, Sun Oil Company; **Combustion,** Dr. John P. Longwell, Esso Laboratories, Process Division, Standard Oil Development Company; **Lubrication and Wear,** E. M. Phillips, Aircraft Gas Turbine Division, General Electric Company; **Compressors and Turbines,** Prof. Howard W. Emmons, Harvard University; **Engine Performance and Operation,** Arnold H. Redding, M.I.A.S., Flow Research Section, Aviation Gas Turbine Division, Westinghouse Electric Corporation; **Heat-Resisting Materials,** Arthur W. F. Green, Chief Metallurgist, Allison Division, General Motors Corporation; **Rocket Engines,** Dr. Maurice J. Zucrow, A.F.I.A.S., Professor of Jet Propulsion, School of Mechanical Engineering, Purdue University; **Aircraft Structures,** Charles R. Strang, A.F.I.A.S., Chief Strength Engineer, Douglas Aircraft Company, Inc.; **Aircraft Loads,** Jerome F. McBrearty, M.I.A.S., Division Engineer, Structural Engineering, Lockheed Aircraft Corporation; **Vibration and Flutter,** Martin Goland, M.I.A.S., Associate Director for Engineering, Midwest Research Institute; **Aircraft Structural Materials,** Edgar H. Dix, Jr., Assistant Director of Research, Aluminum Research Laboratories, Aluminum Company of America; **Meteorological Problems,** Dr. F. W. Reichelderfer, I.A.S. Honorary Member and Fellow, Chief, U.S. Weather Bureau; **Icing**

(*Continued on page 72*)

I.A.S. Welcomes Two New Corporate Members

Aviation Engineering Corporation

The Aviation Engineering Corporation, which employs about 200 persons in its 20,000-sq.ft. plant at Woodside, N.Y., operates under the trade name of Avien. The first product of this company—founded in 1948—was an electronically operated capacitance-type fuel gage that measures fuel quantity by weight and has no moving parts.

Avien has been active in the development of more accurate fuel gaging instruments for aircraft application and has designed and produced a number of instrumentation systems to operate in conjunction with the fuel gage. Among these are systems for totalizing a number of individual gage indications, a precision center-of-gravity control for the distribution of fuel weight in accordance with a predetermined pattern, a system for the compensation of fuel-temperature errors, and switching systems to permit the reading of individual tank quantities on a single indicator by the use of a selector switch. Avien fuel gages are currently either specified for or used by more than 40 different types of aircraft, ranging in size from small helicopters to the largest bombers and transports.

The company also manufactures a cylinder-head temperature indicator that operates on a self-balancing-bridge principle and an electronic level switch that senses the fuel level without the use of any moving parts. Among other products in the late stages of development are a jet-engine gross-thrust indicator and an exhaust-gas jet-engine thermometer. This thermometer takes the output of one or more thermocouples and, by use of a self-balancing-bridge circuit, indicates the tailpipe temperature.

The Bristol Aeroplane Company of Canada Limited

The Bristol Aeroplane Company of Canada Limited was established a comparatively short time ago as a subsidiary of The Bristol Aeroplane Company, Ltd., of Great Britain. The primary purpose of this subsidiary is to make available to Canada all of the technical resources and aviation products of the parent company.

The British parent company first entered the aircraft engine overhaul field in Canada when it acquired the British Aeroplane Engines Limited, of Vancouver, B.C., in 1950. In July of that same year, the old established aircraft engine repair plant of Canadian Wright Limited of Montreal, Que., became a member of the Bristol group of companies. These two strategically placed companies were renamed Bristol Aeroplane Engines (Western) Limited, of Vancouver and Bristol Aeroplane Engines (Eastern) Limited, of Montreal.

These two divisions of The Bristol Aeroplane Company of Canada—Bristol Aeroplane Engines (Western) and Bristol Aeroplane Engines (Eastern)—are currently engaged in the engine overhaul programs for the Royal Canadian Air Force, the Royal Canadian Navy, and various civilian operators of Canada.

Bristol Aeroplane Engines (Eastern) Limited has approximately 40,000 sq.ft. of overhaul area and three large test cells capable of testing engines of over 2,000 b.hp. Bristol Aeroplane Engines (Western) Limited is equipped with one of the largest modern test cells in Canada. Other facilities at the Vancouver division, which has 32,000 sq.ft. of overhaul area, include a recently installed injector test rig and accessory-gear-box testing equipment.

Editorial

One Task Before Us

It is a great honor to be named President of the Institute of the Aeronautical Sciences. Our organization has done much to foster the interchange of information among the nations of the free world. The I.A.S. has an important function to perform, and it has done it well. I hope 1952 will bring many new opportunities for us to contribute our share to the struggle now going on in this troubled world.

I must admit to a slight amount of prejudice, but I can think of no field of human endeavor which offers a greater challenge and, at the same time, a greater sense of contributing to the solution of the free world's problems than this aviation business.

These are not happy times. International tensions and national uneasiness have made all of our tasks more complex. It used to be axiomatic that the engineer during war years became the man of the hour and fell into a sort of "forgotten man" category with the coming of peace. This state of affairs, fortunately, no longer holds true. The engineer now seems assured of his rightful place in society no matter what the state of the world.

The war-bred technological developments have led to a whole new world of possibilities for civilian exploitation. World War II radar led to the vast new TV industry and the countless peacetime uses of radar itself. The atomic bomb, in its frightening power, may lead to new and better living for all of us if it can be harnessed successfully. These are only a few; there are many other developments probably just as important.

Engineering as a career, it seems to me, is now in need of a selling job. You all know of the mad scramble that goes on when a new crop of youngsters graduates each year from our colleges and universities across the nation. Far from being the forgotten man of a few years ago, the engineer has emerged as the man of the hour for wartime as well as peacetime. The profession

I.A.S. President
Wellwood E. Beall
of Boeing

is assured of its rightful place in our scheme of things. The old political catch phrase, "a chicken in every pot," may well be replaced by a new one—"an engineer for every housewife." Opportunities for all types of engineering graduates are virtually limitless.

Here is an example of what is happening. Taking the actual aeronautical engineering school enrollment and graduates for the year 1950 and taking present enrollment and projecting a curve over the next few years, we see that graduates in 1952 will be less than half the number of those graduated in 1950. Further projecting these figures to 1955, it is apparent that the available graduates fall far short of even the 1950 figure. To me, this means that we, as the senior aeronautical engineering society of the nation, have a job to do.

Somehow we must get the word to the youngsters in high school that the engineering profession offers a real future. We must put on a sales campaign. Perhaps we also should do more to assist more directly the various colleges and universities in their aeronautical engineering programs. I feel sure that there are many things we can do, and have not yet done, to bring about a renewed interest in aeronautical engineering as a promising and challenging profession.

We should look on this as a means not only to solve the immediate problem of obtaining sufficient engineers to meet a current work load, but also to meet the very real threat posed by expanding aviation research and production activities going on behind the Iron Curtain.

It seems fitting that we, both individually and as a society, should do our utmost to resolve some of these problems. Surely there can be no better resolution for the new year or no better program for the Institute than to better itself and the free world by making the best use of our combined talents in such a manner.

Wellwood E Beall

A Synopsis of the Technical Sessions *at the 20th Annual Meeting*

NUMEROUS "FIRSTS" were established at the Institute's 20th Annual Meeting this year, and many old records fell by the wayside. To begin with, it was the first time in I.A.S. history that five full days of technical sessions had ever been scheduled for a meeting program. Records of attendance and total registration set an all-time high. The papers presented—both in quantity and quality—have never been surpassed.

With several simultaneous sessions scheduled and such a wide variety of subjects covered, the job of reporting the entire meeting was considered impossible for any one man. The following reports, therefore, represent the combined efforts of 13 different authors—each an expert in his field and the chairman of the particular session covered. The editors of the REVIEW acknowledge with gratitude the cooperation of these chairmen in preparing these reports for publication.

The report on the Electronics Symposium, held on the evening of January 30, has been purposely omitted. This will appear as a separate article in the Special Electronics Issue of the REVIEW next month.

W.A.S.

AERODYNAMICS—I

by

William R. Sears

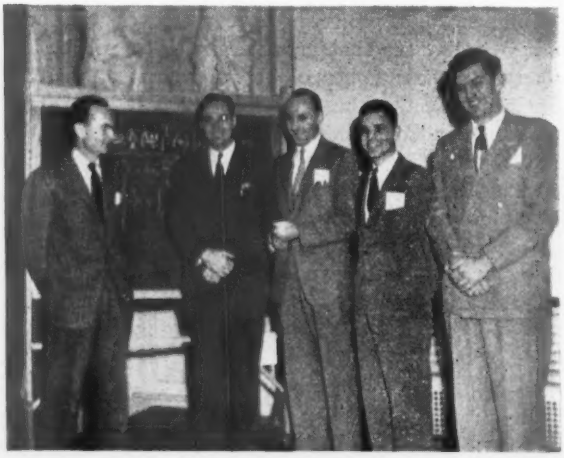
Director, Graduate School of Aeronautical Engineering, Cornell University

The first Aerodynamics Session began at 9:00 a.m. on a cold, wet Monday morning, but the dreary weather failed to detain a "full house" of members and guests who arrived early and participated with enthusiasm. The first three papers were devoted to boundary layers at high speeds and were especially pertinent to current problems of missile design; the fourth paper brought us back momentarily to classical dynamic stability of airplanes.

Dr. Edward R. Van Driest is an aerodynamicist at North American Aviation's Aerophysics Laboratory. He has been concerned with these problems of boundary layer at high speeds for some years now. In his new paper, entitled "Calculation of the Stability of the Laminar Boundary Layer in a Compressible Fluid on a Flat Plate with Heat Transfer," he explored the matter of laminar boundary-layer stability over a wide range of Mach Numbers, including the effects of heat removal and addition at the body surface. This work is based on the important *N.A.C.A. Technical Note No. 1115* by Lees and Lin (1946), where the response of the laminar layer to small disturbances was analyzed. There is both an inviscid solution and one which includes the effects of viscosity.

Briefly, Van Driest's results show that complete stabilization of the laminar layer might be accomplished by wall cooling up to a flight Mach Number of 9, but not above. The viscid and inviscid solutions agree pretty well at supersonic speeds. Some experimental confirmation seems to be afforded by certain data obtained by Fischer and Norris from V-2 firings.

There was lively discussion of this paper. A representative of another laboratory reported that his group has made findings that confirm Van Driest's. The mechanism by which a layer might change from turbulent to laminar in flight was queried; Mr. Joseph Sternberg (see below) described the process as a rearward motion of the transition—the turbulence is blown away. An important theoretical warning was sounded by Dr. C. C. Lin, who remarked that an approximation involved in the Lees-Lin theory would seem to invalidate the viscous solution for any Mach Numbers above about 1.5. The audience was amused by a discussion of this point between Professors Lees and Lin.



The second speaker was Mr. Sternberg, who is Chief of Supersonic Wind Tunnels at the Ballistic Research Laboratories, Aberdeen Proving Grounds, and already an old hand in the aeroballistics business. His paper was closely related to Van Driest's and bore the title "A Free-Flight Investigation of the Possibility of High Reynolds Number Supersonic Laminar Boundary Layers." It reports on a V-2 firing made especially to explore boundary-layer transition. For this purpose, a smooth conical nose was fitted to the rocket, and the missile was fired in a low trajectory to achieve high Reynolds Numbers. Sternberg brought along a film record of the flight which clearly showed the nearly horizontal flight path and the unmistakable "cooking" of the surface paint during the last part of the flight and which ended in a blaze of glory when the V-2 exploded at a Mach Number of 3 at 24,000 ft., for unknown reasons, after about 50 sec. of flight. Instrumentation was provided to measure skin temperatures and also boundary-layer thickness. The results indicate that the layer was laminar for the last 6 sec. of the flight. This appears to be in agreement with theory (e.g., the paper reported just above and also earlier calculations on the same subject by Lees), since the thermal lag of the skin temperature in such a flight causes a great deal of heat removal from the boundary layer.

Discussion of Sternberg's important and well-presented paper was actually a continuation of the earlier discussion, and several comments were made about the Lees-Lin stability theory. Both Professor Lees and Dr. Max Munk emphasized that the theory is not one of boundary-layer transition, for the sequence of events between instability and actual turbulence is still unknown. Thus, calculated *stability* may mean absence of transition, but calculated *instability* may be practically meaningless. Dr. Munk also questioned the applicability of these theories to so rapidly varying transient processes as the present V-2 flight.

Our third paper of the morning was especially appropriate after Dr. Munk's emphasis on the transient problem. It was entitled "The Effect of Nonuniform Surface Temperature on the Transient Aerodynamic Heating of Thin-Skinned Bodies" and is the work of two young Research Physicists at Hughes Aircraft Company, Dr. A. E. Bryson, Jr., and Dr. R. H. Edwards. Dr. Bryson presented the paper in rather brief fashion, apparently feeling that the mathematical nature of the analysis was not suitable for oral presentation. The transient heat-transfer problem is an extremely important one, for which the practicing aerodynamicist has been relatively poorly provided with theoretical methods to date.

The Bryson-Edwards approach is essentially a quasi-steady one, which is based on Lighthill's theory of heat transfer from nonisothermal surfaces in the steady case. Lighthill gives the local heat-transfer rate as an integral over the surface from the leading edge back to the point under consideration. For thin skins, neglecting the heat flow in the skin, the local heat-transfer rate is just proportional to the rate of change of the local skin temperature. Bryson and Edwards simply equate these two expressions for the rate, interpreting all the symbols in Lighthill's formula as instantaneous.

They have solved the resulting equation in several typical cases and have presented their results in comparison with the results of simpler engineering approximation—namely, to use an isothermal-plate formula instead of Lighthill's integral. Actually, the agreement of calculated wall temperatures is not bad, which may indicate that the effects of temperature gradients are not great. But curves of the heat-transfer coefficient itself, calculated by the two approximations, are not in good agreement. (As in all such variable-temperature cases, one result of using this coefficient, based on the local skin-to-stream temperature difference, is a sort of man-made singularity at the point where this difference happens to be zero.)

The morning's final paper was a return, at least temporarily, from the high Mach Numbers and high temperatures of missile boundary layers to a more traditional concern of the aerodynamicist: lateral stability of airplanes. It was a paper by three engineers of N.A.C.A.'s Langley Laboratory, Messrs. R. O. Schade, O. B. Gates, Jr., and J. L. Hassell, Jr. Their contribution is entitled "The Effects on Dynamic Lateral Stability and Controllability of Large Artificial Variations in the Rotary Stability Derivatives" and reports on work done in Langley's ingenious free-flight wind tunnel. Actually, this paper represents an extension of lateral stability measurements into regions far outside the scope of conventional methods, for it was done with tiny rate gyros mounted on the free-flight tunnel models, which actuated the model control surfaces (rudder and ailerons) to produce large variations of the derivatives. The five derivatives studied are those usually called C_{n_r}, C_{n_p}, C_{l_r}, C_{l_p}, and $C_{n_{\dot{p}}}$; i.e., the yawing and rolling moments due to yawing and rolling velocities and the yawing moment due to rolling acceleration.

In each of the cases, Mr. Schade, who presented the well-organized report, showed the results of calculations of damping or divergence factors as influenced by the rate derivatives and other parameters and followed this with motion pictures of the flight of the model in the tunnel. In most cases, good agreement with calculation was found.

The main idea of this investigation was to find ways of improving the damping of the oscillatory mode, which was purposely unsatisfactory in the basic configuration without gyros. The most promising derivative for this purpose turned out to be C_{n_r}, the damping in yaw. Some of the others caused violent spiral instability—the model operator could not prevent crashes into the tunnel walls—or excess stiffness in aileron response. The detailed results will deserve careful study by engineers concerned with automatic stabilizing devices in both conventional aircraft and missiles.

AERODYNAMICS—II

by

Harold Luskin

Assistant Supervisor, Aerodynamics-Research, Douglas Aircraft Company, Inc., Santa Monica Division

The Aerodynamics—II Session of the Twentieth Annual Meeting of the Institute of the Aeronautical Sciences was held on the afternoon of Monday, January 28, 1952, in the North Ballroom of the Hotel Astor in New York City. About 500 members and guests of the Institute attended the session. Engineers and scientists from industry and Government agencies and teachers and students from many schools were in the audience. The four papers that made up the program gave consideration to supersonic flow, wind-tunnel design, a scheme for visualizing flow, and boundary-layer calculations.

The first paper of the session considered a problem in two-dimensional supersonic flow theory. The paper, "On Weak Interaction of Strong Shock and Mach Waves Generated Downstream of the Shock," was prepared and given by Boa-Teh Chu, Graduate Student, Department of Aeronautics, Johns Hopkins University. A study was described which was intended to be an improvement on the Ackeret-Busemann theory for two-dimensional supersonic flow. In that theory, all disturbances, whether expansions or compressions and of a magnitude consistent with the requirement that the waves be weak, are propagated into the flow at the Mach angle. All of the waves are Mach waves. In actuality, however, the compression waves have an inclination that is not generally the same as the Mach angle, while the expansions likewise are propagated at angles slightly different from the Mach angle. This lack of parallelism allows some of the waves to intersect. The resulting interaction, neglected in the Ackeret-Busemann theory, is considered here for the case of intersection of a shock wave with Mach waves generated downstream of the shock. The solutions were obtained analytically and show that Mach waves are reflected from the shock wave without change of sign but with reduced amplitude. The "reflection index" approached zero as the shock wave degenerated into a Mach wave and increased monotonically as the shock strength to a maximum of slightly less than unity. The interaction of shock wave and Mach waves generated by a small protuberance on the wedge surface produced an almost similar image on the shock wave with the longitudinal and transverse scale stretched in proper ratio. Fig. 1 illustrates this example. The shock wave also was shown to behave like a porous elastic structure that deformed under a simple stress-strain relation. The solution was applied to calculate the pressure distribution on a "supersonic airfoil" at large angle of attack.

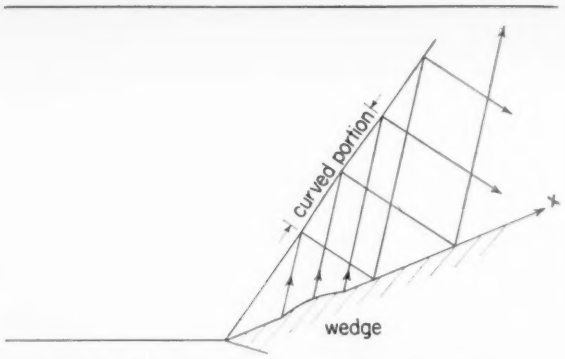
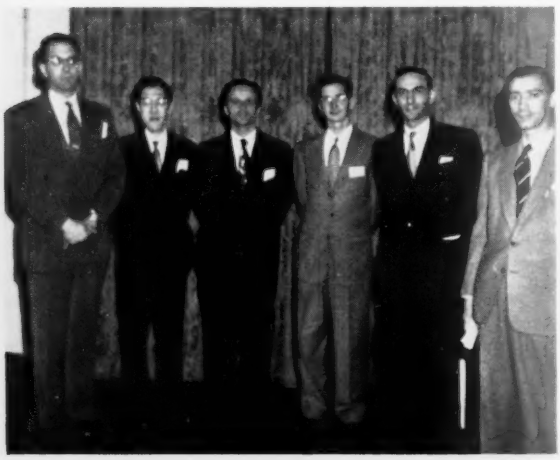


FIG. 1. Supersonic flow over a wedge with a bump.



The last decade saw the design and development of many supersonic wind tunnels. Many studies were therefore made on the flow processes that occur in the tunnel diffuser. The second paper of the session, entitled "Diffuser Efficiency of Free-Jet Supersonic Wind Tunnels at Variable Test Chamber Pressure," by Rudolf Hermann, Professor, Department of Aeronautical Engineering, University of Minnesota, considered the case of the free-jet tunnel diffuser. The study deals with the situation in which the test chamber pressure is different from the nozzle exit pressure. Analytical relations were obtained using the theory of one-dimensional, nonviscous, steady flow. Diffuser efficiency and other flow parameters were calculated for variable chamber pressure in a Mach Number range from 1 to 10. The mechanism of test chamber pressure control by means of the adjustable diffuser throat was shown. The stability of the chamber pressure was proved, and a quantitative description of a "slow-starting" process of the tunnel was given.

The fact that air is an invisible gas has always made it difficult for scientists to carry out flow studies properly. It has only been in comparatively recent times, for example, that it has even been recognized that air is a substance. A technique for visualizing the flow about aerodynamic bodies at low speeds was described in the paper entitled "Visualization of Flow Fields by Use of a Tuft Grid Technique" by John D. Bird, Langley Aeronautical Laboratory, N.A.C.A. In applying the technique, photographs were taken far downstream of the body of a great number of tufts of uniform length mounted on a screen. Fig. 2 shows the general arrange-

ment of the equipment. The procedure permitted obtaining, in an approximate manner and with small effort, a vector plot of the flow field in a plane normal to the air stream at a station behind an aerodynamic surface. The general range of usefulness of this technique in providing physical explanations for the character of force-test data and in visualizing aerodynamic phenomena was discussed, and examples of the application of the technique to particular problems related to the chordwise growth of lift and interaction of combinations of lifting surfaces were given. Interesting moving pictures showing the results of surveys behind various aerodynamic forms were employed for illustration. Fig. 3 portrays the development of the flow field behind a delta wing.

The final paper of the day was entitled "Simplified Laminar Boundary-Layer Calculations for Bodies of Revolution and for Yawed Wings" by N. Rott, Associate Professor of Aeronautical Engineering, and L. F. Crabtree, Research Assistant in Aeronautical Engineering, Graduate School of Aeronautical Engineering, Cornell University. The paper was presented by Dr. Rott. This work is based on the momentum methods for boundary-layer calculations originally suggested by von Kármán and Pohlhausen but more specifically based on the work of Thwaites. Instead of beginning by specifying the nature of the boundary-layer profiles, Thwaites suggested the use of the momentum equation, combined with the assumption of a one-parameter family of profiles. Thwaites applied the method to calculations of the two-dimensional laminar boundary layer. The present paper showed that the method could be readily extended to unyawed bodies of revolution. Furthermore, an application to yawed infinite wings was presented; here, a consideration of the "mixed" momentum thickness of the three-dimensional flow was required. After a general discussion of the relationship of this quantity to the chordwise-flow parameters, its dependence was specified after inspection of known exact and approximate solutions for infinite yawed cylindrical bodies. A functional relationship was found by which the actual calculation of the spanwise boundary-layer flow was reduced to a quadrature. Examples were given of the practical application of this technique.

A discussion of the corresponding procedures for turbulent boundary layers cast some light on the significance of the well-known difficulties in this case.

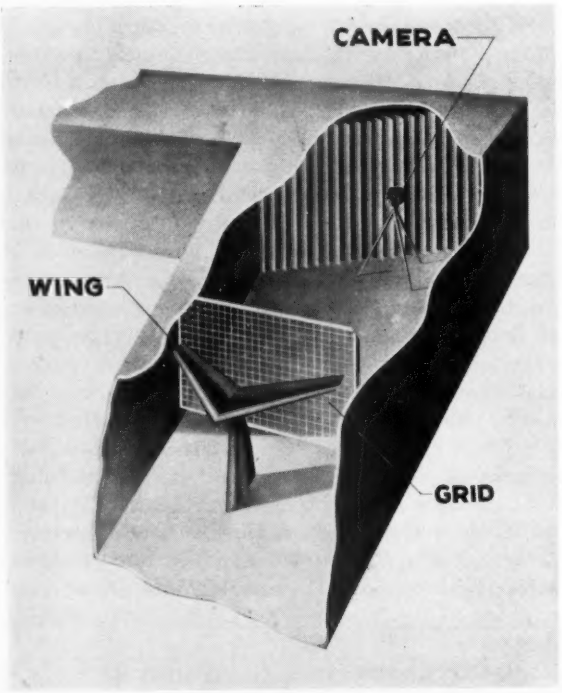


FIG. 2. Apparatus for tuft grid technique.

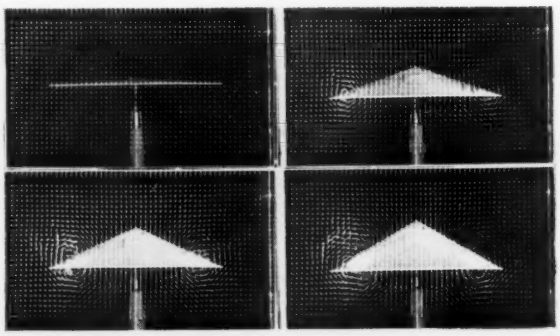


FIG. 3. Flow behind a delta wing as made visible by a tuft grid.

AEROELASTICITY

by

A. H. Flax

Head, Aerodynamic Research Department, Cornell Aeronautical Laboratory, Inc.

This year's Annual Meeting marked an auspicious occasion for the Aeroelasticity Session, in that it was given a place in the morning program, after several years of existence, all limited to the nocturnal hours. There has perhaps been the feeling in some quarters that aeroelasticians are practitioners of a weird and occult art, who need to perform their strange rites by the light of the moon in proximity to the witching hour. Now that the subject has been aired in the bright light of day, it is to be hoped that at least some of this feeling may have been dispelled. For not only the daylight but also the lecturers served to illuminate many of the matters under discussion. In addition, as compared to past sessions, the large reduction in the yawn rate must have been highly gratifying to speakers and audience alike.

The first paper was "An Approach to the Buffeting Problem from Turbulence Considerations" by H. W. Liepmann, Consultant, Douglas Aircraft Company, and Professor, Guggenheim Aeronautical Laboratory, California Institute of Technology. This was a rather unusual paper, in that Professor Liepmann employed

statistical techniques hitherto more familiar to communications engineers than to aeronautical engineers. He made it clear, however, that the paper was aimed as much at introducing these techniques as at the treatment of the buffeting problem. Specifically, the new techniques employed were those of the theory of stochastic processes, including the concepts of stationary time series, power spectral density, and correlation functions. Professor Liepmann introduced all these notions to an audience largely unschooled in such matters with a minimum of mathematics and succeeded in leaving at least a qualitative idea of the analysis involved with a surprising number of his listeners.

A simplified model of the buffeting problem was then considered, using the concepts introduced in the earlier part of the lecture. The lift forces on a two-dimensional thin airfoil moving in a field of isotropic turbulence were studied, and results for mean square lift coefficient in terms of parameters describing the turbulence were obtained. Some aspects of more complicated models for the buffeting problem were also discussed briefly.

In the discussion period, the general feeling was expressed by several discussers that the techniques illustrated in the paper might well prove to be powerful tools. In particular, the aircraft gust problem seemed to be amenable to such treatment. Dr. N. Frenkiel of the Applied Physics Laboratory, Johns Hopkins University, pointed out the need for care in selection of appropriate time intervals for establishment of the stationary character of the time series. Professor Liepmann replied that in many physical problems with which one might be concerned, as, for instance, the effects of gusts on an aircraft in a localized turbulence condition, the situation was probably well enough defined to permit his methods to be employed.

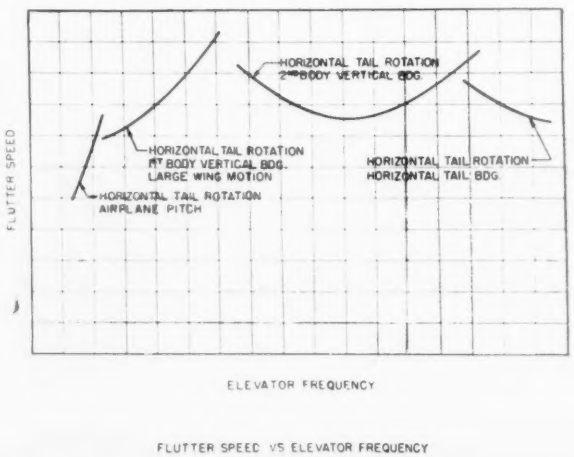
The second paper was "Flutter Analysis of Complex Airplanes by Experimental Methods" by E. Berkeley Kinnaman, Vibration Unit Chief, Boeing Airplane Company. The paper dealt with some of the results obtained by Boeing from its comprehensive wind-tunnel flutter test program on relatively flexible swept-wing airplanes carrying large concentrated masses on the wings. The lecture was supplemented by an interesting motion picture illustrating some of the modes of flutter experienced in the wind tunnel and including some dramatic model failure scenes.

The flutter models employed in the tests were aeroelastically similar to full-scale aircraft in most of their major components. Further, they were mounted in the wind tunnel with the maximum of rigid body freedom. Thus, many modes of flutter were possible, and some significant results were obtained, showing transitions between several modes of flutter with progressive change of a single parameter. Also brought out were several instances of great sensitivity of the flutter speed to a small change in one of the configuration parameters.

Unfortunately, due to the combined length of the paper and the accompanying motion picture, it was not possible to allow time for discussion of this paper, although several members of the audience were anxious to speak.

The next paper, "An Analysis of the Effect of a Power-Boost System on Wing-Torsion Control-Rotation Flutter," by Robert H. Barnes, Aeronautical Research Scientist, Ames Aeronautical Laboratory, N.A.C.A., dealt with a problem of considerable current interest because of the increasing use of power boosts and servo controls. The author considered the coupling of a power-boost energy source to an aeroelastic system through the medium of structural deformation of the power-boost linkage and supports. Flutter speeds for a simple system of this type involving the wing-torsion and control-rotation degrees of freedom, in addition to the boost system itself, were obtained employing an analog computer. The results indicated that, in some cases, marked reductions of the flutter speed may be brought about by the type of coupling considered.

The final paper of the session, "The Calculation of Spanwise Loadings for Oscillating Airfoils by Lifting-Line Techniques," by M. A. Dengler, Research Engineer, and Martin Goland, Associate Director for Engineering, Midwest Research Institute, dealt with the perennial problem of simplifying the calculation of aspect-ratio



FLUTTER SPEED VS ELEVATOR FREQUENCY

FIG. 3. (Kinnaman paper) Flutter variations as a function of elevator rotation frequency.

corrections for oscillating wings. Mr. Goland presented the paper in clear and concise form, without going into any of the details of the analysis. The authors of this paper were seeking a method of calculation suitable for extension to oscillating swept wings, but, in order to compare the proposed theory with existing theories for unswept wings (the theories of Cicala and Reissner, Reissner's being the more accurate of the two), they confined their preliminary investigation to rectangular wings. The authors name the Prandtl steady-flow theory a "quasi-surface theory" and reserve the name of "lifting-line theory" for the Weissinger L method. Using the terms in this sense from here on, the authors effected a formal extension of the Weissinger lifting-line theory to nonstationary flow on the assumption that the wake starts from the quarter-chord line. The results were found not to be in agreement with existing theories, but they could be brought into fair agreement simply by arbitrarily assuming the bound vorticity to be shifted in phase by a certain factor. Logical justifications for this shift in phase are then proposed, one of the important points being that the wake actually starts from the trailing edge and not from the quarter-chord line. The modified theory still reduces to Weissinger's in the steady case. The theory can be extended to swept wings, but tabulations of the extended Cicala F functions will be required before numerical results can be obtained.

In the discussion, the authors were congratulated on having obtained an interesting and apparently workable solution of the problem; Professor Holt Ashley, Massachusetts Institute of Technology, commented on the extreme difficulty of the problem and the slowness of progress in the field. Mr. Rheinhardt Rosenberg, Boeing Airplane Company, pointed out that, since in the two-dimensional theory the free vortices in the wake started from the trailing edge, it would seem only reasonable to put it there in the three-dimensional case as well. Mr. Goland stated that they did not do this originally because they wanted a lifting-line theory in a true sense, and this would have introduced surface considerations. Mr. R. T. Jones, Ames Aeronautical Laboratory, N.A.C.A., inquired as to whether the authors had considered attacking the problem employing the idea of the wing growing in chord, such as he had introduced in his treatment of the lift of an elliptical wing. Mr. Goland replied that he was aware of Mr. Jones' method, but that he considered the approach used in the paper more generally applicable to the swept-wing problem, for instance. Mr. H. R. Lawrence Cornell Aeronautical Laboratory, Inc., objected to the identification of the Prandtl lifting-line theory as a "quasi-surface theory" while at the same time, the Weissinger theory was called a "true lifting-line theory." Mr. Lawrence asserted that the Weissinger theory was a closer approximation to lifting-surface theory than Prandtl and that it was confusing to ignore its surface character; in particular, he pointed out that such things as the correct location of the wake starting point would be immediately apparent if the extension of the Weissinger theory were viewed in this light. Mr. Goland disagreed with this point of view and stated that he felt that his classification of the Prandtl and Weissinger theories was the more logical, based on the procedures by which he derived them. Since the lunch hour had by then arrived, there was not time to pursue this point further during this session, and the meeting was adjourned.

MOTORLESS FLIGHT

by

Ben Shupack

Aerophysics Institute, Inc.

The session on Motorless Flight seems to be an island in a sea of powerplane sessions, but closer inspection shows that the line of demarcation between the problems of powerplane flight and motorless flight is fast disappearing. A case in point is the problem of improving aircraft performance. Up to now, powerplane performance was improved primarily by increasing thrust, but it is becoming increasingly difficult to get more thrust so that the approach to increased performance has become that of motorless flight where the only way to improve performance is to strive for drag reduction.

Another illustration is the problem of clear air turbulence, which is so disturbing to civil and military aviation. The devotees of motorless flight initiated the investigation of this phenomenon, for they are ever eager to find new sources of atmospheric energy. But with the increased traffic at high altitudes, both groups are busy trying to learn all they can. All this justifies the definition of soaring by A. Raspet as "the extraction of energy from atmospheric sources by means of sailplane."

A new source of energy for long-distance soaring was discovered and reported by Joachim Kuettner of the Air Force Cambridge Research Center. The paper describing this discovery was titled "On the Possibility of Soaring on Travelling Waves in the

Jet Stream." It was presented in behalf of the author by Paul B. MacCready, Jr., of the California Institute of Technology, a soaring pilot of considerable fame with personal experience in soaring in atmospheric waves.

Kuettner's discovery was reported chronologically, giving the logic at each stage. His first inkling that traveling waves exist in the jet stream came from microbarographic traces when on the ground. On a sailplane flight to the upper troposphere, Kuettner encountered these waves and made measurements where the wind speeds in the waves were obtained from drift observations and the air speed of the sailplane.

A theoretical analysis showed that conditions for the existence of traveling gravitational waves in the jet stream were fulfilled in a duct of rather small thickness due to the peculiar vertical round profile of the jet stream. This duct is bounded above and below by unstable layers in which heavy turbulence can develop. The author showed data from a sailplane flight under these conditions. Of significance to transport aviation was his speculation that this phenomenon might be the cause of clear air turbulence that is so often met by airplanes cruising at high altitudes.

Based on Kuettner's theory, clear air turbulence could be predicted for certain portions of the jet stream. Pilots could then be warned not to fly through these regions.

In the discussion of Kuettner's paper, Capt. R. S. Barnaby (U.S.N.) asked how a correlation between jet stream waves and ground pressure measurements was effected. MacCready replied that a certain type of large amplitude pressure oscillations occurs only with jet stream conditions. MacCready also pointed out in the discussion that discoveries such as Kuettner's result from the inquisitiveness of sailplanists about peculiarities occurring during their so-called "sporting flights." Efforts to explain many of these phenomena lead to new knowledge.

Asked why sailplanes, and not airplanes, are used for such researches as that on jet stream waves, MacCready replied that airplanes have been used to study clear air turbulence when large regions must be covered but that, if it is desired to measure accurately the amplitude and wave length of the clear air turbulence waves, a more sensitive instrument such as a sailplane must be used.

The paper by A. Raspet, Mississippi State College, on "Boundary-Layer Studies on a Sailplane" covered a research on improving the lift and reducing the drag of a wing by means of suction at a trailing-edge slot and by means of suction through a perforated surface.

A two-place war surplus Schweizer TG-3A sailplane was fitted with a carefully contoured leading edge over a short test section on the inboard portion of one wing. By means of a battery driven blower, suction could be applied to a slot at the trailing edge of the wing. The effect of suction on the lift coefficient was determined by pressure distribution measurements around the wing, and the effect on profile drag was determined by the momentum loss method. Transition determinations were made by the relatively simple stethoscopic method developed at the Aerodynamic Institute at Zürich. From transition determinations and momentum measurements, it was shown that trailing-edge suction acted as a means for separation prevention. Pressure drag was reduced at the high lift coefficients.

The large increases in lift coefficient reported in German work on trailing-edge suctions, using relatively small suction quantities, were not found in the flight measurements reported by Raspet. A full span test is being set up to determine if end losses on the test section were the cause of the small lift coefficient increment due to suction.

Four flight induced suction sources were mentioned: the low-pressure region at the rear of the fuselage, the wing tip upper surface, a tip body of revolution, and a windmill driven blower.

For trailing-edge suction, the wing tip source was shown to be the most satisfactory; however, for boundary-layer control by porous suction, the windmill alone fulfilled necessary requirements.

A unique method for achieving area suction was used to stabilize the laminar flow to the trailing edge of the wing. The porous area was produced by punching holes in the fabric portion of the wing with a needle. The flexibility of this process permits varying the porosity in such a way that a minimum of suction is needed. Also, by this arrangement, the entire interior of the after portion of the wing is used as a duct. Ducting losses are thus kept low, and only one pressure source is needed. For a porosity distribution—admittedly not a most economic one in regard to suction quantity requirement—the pricked hole technique permitted the upper surface of an NACA 4416 airfoil to be held laminar to the trailing-edge slot at 95 per cent with a suction on quantity coefficient C_Q of 0.00049. The author felt that this quantity could be reduced considerably.

The research on the sailplane revealed that a maximum chordwise spacing of the rows of holes of 0.25 in. had to be used if the stabilization of the boundary layer was to be achieved.

It is interesting to learn that, even at Reynolds Numbers of 2 to 4 million, the considerable overall profile drag decrease of 53 per cent was affected. The minimum profile drag coefficient, including the power required for suction, was found to be 0.004 at Reynolds Number = 2.5×10^6.

In the discussion it was asked what the source of suction would be on a sailplane fitted with boundary-layer control utilizing porous suction and what gain in performance could be expected. The windmill driven blower was suggested as a practical solution, since it has an efficiency of about 50 per cent. A venturi, though much simpler, unfortunately has

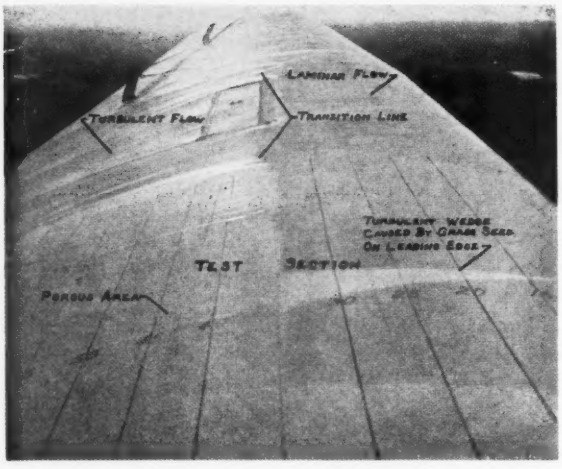


FIG. 9a. Demonstration of transition by dew evaporation method on sailplane TG-3A with suction blower off at lift coefficient = 0.681.

an efficiency of only 4 per cent. On an airplane having as low a drag as an RJ-5, the outstanding American performance sailplane, the performance would be improved by 33 per cent for area suction on the top surface only. If also applied to the lower surface, even higher gains can be expected.

In reply to R. Hermann's question as to how long the evaporating dew transition detection, shown in Fig. 9-A, persists, the author stated that the longest period was 6 min., but the shortest was not less than a minute after the take-off. A paper contemporary to that of Raspet was presented by Jones and Head at the Brighton meeting. Jones and Head succeeded in stabilizing in flight the laminar boundary layer under uniform pressure. Raspet demonstrated stabilization in the adverse pressure gradient on the top surface of a lifting wing.

The efficient utilization of thermal type atmospheric energy with a sailplane was discussed by Bruce Carmichael, Senior Aerodynamicist, Goodyear Aircraft Corporation, in his paper, "Cross-Country Soaring Criteria Based in Thermal Strength." Carmichael developed the equation for effective cross-country speed in terms of the vertical air-mass velocities and the still-air performance of the sailplane. Munk's nondimensional polar served as an excellent tool in defining the sailplane still-air performance in that it allowed the results to appear in general form and thus be applicable to any sailplane.

The detailed basic equation suggested two means for obtaining maximum distance flights—namely, (1) the choice of optimum flight speeds between thermals and (2) the adjustment for optimum sinking speed at best glide ratio by controlling the wing loading through the use of water ballast. The optimum values in both cases were dependent upon the meteorological conditions and permitted significant improvements in flight performance.

In flight between thermals, the presentation showed that the speeds increase at a gradually decreasing rate as the thermal strength increased. For example, if the thermal is just strong enough to enable the pilot to maintain altitude in the spiral, he should fly straight at the speed for the best glide ratio. However, if the variometer indicates an ascent of five times the normal sink at best glide ratio, he may fly to the next thermal at 77 per cent in excess of his speed for best glide ratio. In all cases, downdrafts encountered between thermals call for even higher flight speeds. A general chart was presented from which optimum flight speeds between thermals could be chosen as a function of variometer reading for any sailplane for which the sinking speed and flight speed at best glide ratio were known.

The high aspect ratios employed by sailplanes to improve the $L/D_{max.}$ causes the lift coefficients to be high, which in turn results in lower airspeeds. The airspeed may be increased by the use of ballast, but this increase in wing loading also increases the sinking speeds. The solution of the basic equation led to a linear relationship between sink at best glide ratio and thermal strength. It was found best to ballast so that the sink at best glide was about one-third of the vertical velocity of the thermal.

Fig. 4 shows some maximum values of cross-country speed which could be obtained with sailplanes whose maximum glide ratios range from 20 to 40. This illustrates the importance of aerodynamic refinement in the sailplane. These ultimate cross-country speeds are based on constant thermal strength, optimum ballast, and optimum speeds.

In concluding, the author mentioned the successful use of flight-speed determination by recent soaring champions, and a plea was made for systematic investigation of the use of ballast.

In appreciation of his contribution to Carmichael's paper, Dr. Munk was asked to comment on his nondimensional polar. Eight years after its original publication, Munk's paper contributed to a field with which he was not even familiar. Although it was his sincere pleasure to see his paper so used, Munk could not imagine a sailplane pilot flying with a slide rule. MacCready, in reply, described his own development

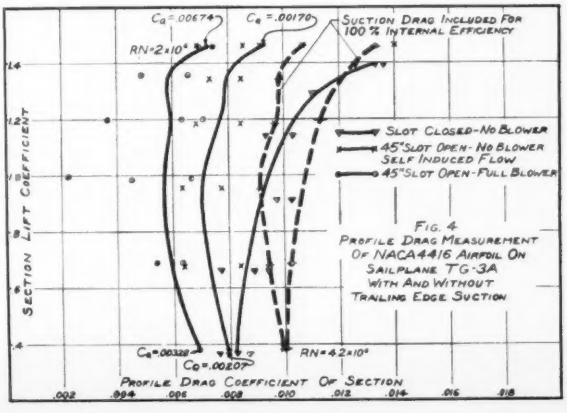


FIG. 4
PROFILE DRAG MEASUREMENT OF NACA 4416 AIRFOIL ON SAILPLANE TG-3A WITH AND WITHOUT TRAILING EDGE SUCTION

of a circular scale for the variometer which automatically solved the cross-country formula for the pilot.

In 1948 at the I.A.S.-S.S.A. Motorless Flight Conference held in Elmira, N. Y., the specifications for an ultimate performance sailplane were laid down. Three years later a sailplane utilizing a laminar airfoil and possessing a high efficiency wingroot intersection and low parasitic drag was completed and found by flight test to have achieved a performance L/D of 40.5. This same sailpane, RJ-5, flown by R. H. Johnson of Mississippi State College in the summer of 1951, broke the international glider distance record of 435 miles held by a Russian girl since 1938. At that same session, Dr. Lippisch proposed a boundary-layer control by trailing-edge suction.

It is evident from the papers presented at this 1952 session that the seeds sowed by the papers presented at the 1948 session have born fruit.

STRUCTURES

by

N. J. Hoff

Head, Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn

The caryatids of the North Ballroom of the Hotel Astor smiled happily upon an unusually large gathering of structures experts which almost completely filled the room. The first speaker, Prof. M. L. Williams of the California Institute of Technology presented an extensive survey of the literature on sweptback wing analysis under the title "A Review of Certain Analysis Methods for Swept-Wing Structures." The paper was unusual because of its bibliography, which contained 63 titles. Only ten of these were printed in engineering periodicals and five as N.A.C.A. technical notes; the majority were research reports of companies and universities and included Professor Williams' own analyses. The author concluded that the airplane industry had enough experimental data and analytical solutions to get by, but a need existed for more accurate and for more rapid approximate methods, particularly for thick shell construction and solid wings of variable thickness.

L. B. Wehle, Jr., and W. Lansing of the Grumman Aircraft Engineering Corporation showed how highly redundant thin reinforced shells can be analyzed in a systematic manner. Their paper had the title "A Method for Reducing the Analysis of Complex Redundant Structures to a Routine Procedure." It made use of matrix methods that have long been accepted as everyday tools by the flutter and vibration experts of the airplane industry. Formulas and curves were given for the computation of the flexibilities of the commoner structural elements, and a complete sample calculation was worked out for the stresses in the root triangle of a sweptback wing with taper in plan form and thickness.

A new type of problem, which may attain importance at the high temperatures to which supersonic missiles will be heated, was discussed by Charles Libove of the Langley Aeronautical Laboratory of the N.A.C.A. in the paper "Creep Buckling of Columns." Starting from an empirical creep formula established from constant load tension tests, the author deduced a creep law for the time-dependent stresses prevailing in the flanges of an idealized initially slightly crooked column. The equations governing the deflections of such a column were derived and integrated for loads smaller than the Euler load, and the time was computed at which the deflection of the midpoint of the column becomes indefinitely large. It was found that the lifetime of the column is much affected by the load and by the initial deviation from straightness.

The last paper on the program was "Analysis of Stiffened Curved Panels Under Shear and Compression" by M. A. Melcon and A. F. Ensrud of Lockheed Aircraft Corporation. It was presented by Mr. Melcon who explained the steps through which the empirical relationships were derived from tests carried out on 50 specimens. The relationships were patterned on fundamental theoretical formulas that were combined in such a manner as to obtain the best agreement with test results. The formulas took into account the interaction between the buckled curved panels (diagonal tension) and the stringers. A number of graphs were presented to show the agreement between the empirical relationships and the tests.

A great deal of discussion followed each paper. Of the discussers, Prof. Joseph Kempner of the Polytechnic Institute of Brooklyn should be mentioned. He pointed out certain limitations to the validity of the creep law adopted by Mr. Libove.

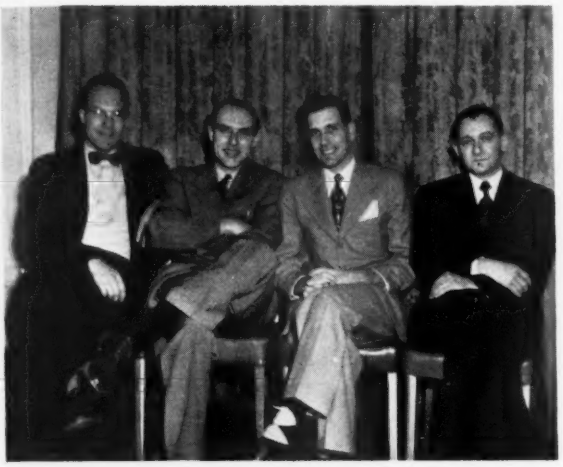
AIRCRAFT DESIGN

by

Richard Hutton

Chief Development Engineer, Grumman Aircraft Engineering Corporation

Three papers were presented at the Aircraft Design Session of the twentieth Annual Meeting of the I.A.S.



in New York. Two dealt with problems that have concerned the industry for many years and continue to give trouble—Icing and Noise. The third paper introduced a new problem—fortunately one specific to military aircraft—that of gun-gas explosions.

The first paper, "Electro-Thermal Methods of Aircraft Icing Protection," prepared by J. L. Orr, C. K. Rush, and J. H. Milsum of the National Aeronautical Establishment, Canada, was ably presented by Mr. Orr, who with his associates flew to the meeting in their test airplane, a Canadian DC 4, popularly known as the "Rockliffe Ice Wagon," named for Rockliffe, an R.C.A.F. base near Ottawa.

The visit of the aircraft and her crew from Canada is a continuation of the spirit of cooperation which exists between ourselves and our friends across the border.

After discussion of experimental deicing equipment and instrumentation installed on the test airplane, an invitation was extended to those interested to inspect the airplane at La Guardia Airport during its stay there.

The various methods of providing protection against icing on the components of aircraft fall into two general categories—anti-icing or ice prevention and deicing or ice removal. The authors feel that the most promising method of protection, particularly with the increase in aircraft speeds, is in the second category—i.e., deicing or ice removal—and that the electrothermal method of accomplishing this offers many advantages over other means. The application of the electrothermal deicing principle to their aircraft was discussed.

While the thermal anti-icing principle maintains full aerodynamic efficiency, the advent of higher flying speeds has increased drastically the heat requirements to accomplish the desired result. It appears, therefore, that if the bulk of the ice formation could be disposed of in the solid state by deicing, rather than in the vapor state as for anti-icing, there would be a great reduction in the energy required for icing protection.

As applied to wings, tail surfaces, etc., the installation developed consists of a continuously heated parting strip centered along the working range of the stagnation line on the leading edge. Located immediately behind this parting strip on both surfaces is an area that is intermittently heated. The ice is allowed to form and is then periodically shed when the liquid interface formed by the intermittent heating reduces the adhesion to a value low enough for the ice to be shed by aerodynamic forces.

Because of its extreme sensitivity to icing, the axial-flow gas turbine presents a critical icing problem. The intake lip and nose bullet can be treated in a manner similar to a wing, but the compressor guide vanes and rotor blades require a different solution.

Tests at the N.A.E. employing internal electrically heated guide vanes have proved to be satisfactory. The application of this method to the rotor blades, however, was not considered practical, and an eddy current or induction heating principle consisting of several electromagnets straddling the rotor blades was employed. One leg of each magnet replaces a guide vane, and the other replaces a stator blade. The power requirements of this system are low, although the weight is appreciable.

The second paper, prepared by H. H. Hubbard and L. W. Lassiter of the N.A.C.A. and presented by Mr. Hubbard, considered the aircraft noise problem from three aspects—its physical characteristics, its effects on speech and hearing, and the protection from noise.

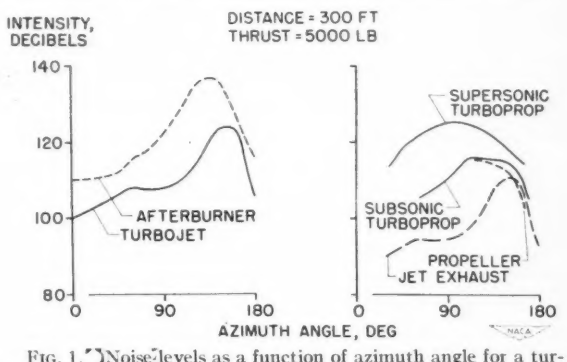


FIG. 1. Noise levels as a function of azimuth angle for a turbojet with and without afterburner and, as estimated, for two different turbopropeller units.

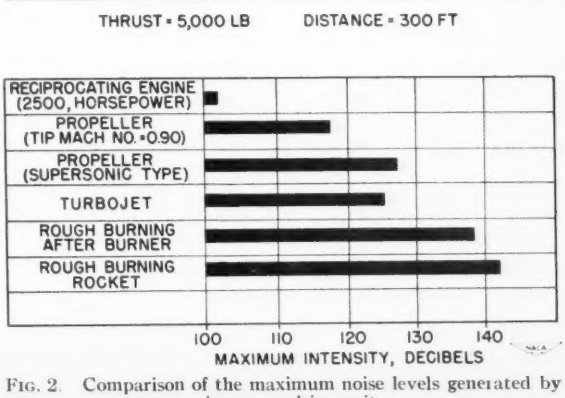


FIG. 2. Comparison of the maximum noise levels generated by various propulsive units.

The main component of propeller noise is the rotational noise generated by aerodynamic forces on the blades, and it was pointed out that the propeller-sound intensity can be reduced by increasing the number of blades and by reducing the tip Mach Number, provided the tip Mach Number is subsonic. At supersonic tip Mach Numbers, a relatively small benefit would result from this method.

While the noise due to engine exhaust on small engines can be coped with adequately, additional research and development are required to produce satisfactory results for large power plants.

The noise source of turbojet engines is mainly the mixing region of the jet. The mechanism of this type of noise is not well understood, but it is known that jet noise is increased as the jet velocity, density, and turbulence is increased. This means that increases in noise from turbojets will occur when the exit gas temperature increases with its higher associated jet velocities, from either improved turbojet designs or application of afterburners to current turbojets.

Since there is considerable interest in turbopropeller units, estimates of the noise level of two different turbopropeller units were made, and the results are shown in Fig. 1. A comparison of the maximum intensities of noise from various sources is shown in Fig. 2.

With the new type of propulsion units under consideration, particularly by the military, the noise problem appears to be getting worse rather than improving.

The problem of providing adequate protection from noise sources was shown to be complicated by the intense low-frequency content of noise from most aircraft power sources.

The third paper concerned a problem that, in retrospect, has been with us for some time but only recently has been recognized—that of explosions in military aircraft due to collection and ignition of residual machine gun gases.

The paper presented by E. Witkin is the result of the work of J. J. Horan, J. R. Onderdonk and E. Witkin, all of the U.S. Naval Air Development Center, Johnsville, Pa.

The characteristic of modern gun powders is such that the gases leaving the muzzle and breech and those leaving with the ejected cases contain a considerable quantity of combustible material, such as hydrogen and carbon monoxide. When diluted with air in the proper proportion and then ignited, they can produce a violent explosion.

Once the problem was recognized, solution was considered along two general approaches, one by methods for preventing the gases from damaging the aircraft and the other by suitable ventilation.

Among the preventive methods considered were controlled burning of the gas before it can accumulate in sufficient quantity to cause a damaging explosion by means of sparking devices or glow coils, but these were considered to add other complications and hazards; and the use of inert diluents or quenchants, such as carbon dioxide, methyl chloride, or nitrogen, but this solution was not attractive because of the quantities required. Exclusion of oxygen from the gun compartment appeared impractical. Catalysts or absorbents or flame screens appeared too bulky and heavy. Mechanical devices, such as spring loaded doors, have proved impractical since they react too slowly.

It therefore appeared that the simplest method of solving the gun-gas problem was to provide adequate ventilating air and distribute it properly and the method by which the required amount of ventilation could be determined was described.

In order to investigate the presence and concentration of the explosive mixture, a detecting system was developed at N.A.D.C. The design and application of this system was described and the criteria established for defining a dangerous condition in terms of space distribution of the gas. The amount of ventilation required to arrive at a safe installation was indicated.

ELECTRONICS IN AVIATION—I

Impact of Electronic Trends on Aircraft Design

by

K. C. Black

U.S. Naval Air Development Center

To most of us, the importance of electronics in aviation is a self-evident fact, and this point was emphasized at various times during the meeting. Using money as a criterion, two examples were mentioned that are worth noting: one, that in one of the modern large bombing aircraft, 40 per cent of the total cost is for the electronic gear alone, and the other, that the electronic equipment in a large modern aircraft is more expensive than the entire aircraft of approximately 15 years ago.

This electronic equipment is, of course, not an unmitigated nuisance. Much of the performance of modern aircraft is entirely dependent on electronics. Communication and navigation are largely accomplished by electronics. As the speed and size of the aircraft increases, the operation of the control surfaces requires

the use of servomechanisms that are either electronic in their entirety or are at least controlled by electronic devices. Certain modern engines begin to have a complexity of controls that look as if they, too, will have to depend on programming methods that, in turn, will depend on electronics for their operation. Summing up these varied thoughts, electronics are inextricably woven into the modern aircraft design, and, according to most forecasts, this trend will continue into the indefinite future. Facts such as these are ample justification for the allocation of a definite part of the Annual Meeting of the Institute to the electronics aspects of aviation.

In planning the three-session electronics day at the 1952 Annual Meeting, the individual sessions had, in turn, individual themes: The morning session concerned itself with the interrelation of certain basic electronic and aeronautical problems or developments. The afternoon session concentrated on problems that result from, or are important in, the high-speed flight of today. At the evening session, the picture was slightly reversed and a panel of experts was called on to answer an assortment of questions having to do with the problems of all-weather flight from the point of view of those concerned with aircraft operation.

The balance of this particular paper will concern itself with a review of the morning session that had as its descriptive title "Impact of Electronic Trends on Aircraft Design."

One of the greatest problems that electronics has imposed upon the aeronautical industry is that electronic devices have grown more numerous and more complicated, until they threaten to become the controlling factor in the design of aircraft. In this, they are like a multiple Frankenstein monster that begins its existence as a servant but threatens to become the master. This growth is a difficult process to check because every new step taken to increase the number or complexity of the devices is justifiable in itself, but the end result is somewhat staggering and definitely appears to be getting out of proportion. An example of modern thinking is that in a recent discussion about a certain new and "vital" device, an estimate was requested as to the number of vacuum tubes that would be added to the aircraft complement. The answer was that this might be 300 to 400. This, in itself, is a disturbing way of making a statement because it shows that a difference of 100 vacuum tubes is now looked upon as a relatively unimportant matter! There was a time when 100 vacuum tubes was the electronics quota for a number of aircraft, and now they merely represent a margin of error in forecasting the complexity of one of many "vital" devices! By increasing the problems associated with size, cost, reliability, heat disposal, and so forth, the electronic monster slowly grows into an even more controlling position.

However, the electronic scientist is not entirely oblivious to the dangers created by the monster, and continuing efforts are made to improve conventional devices. Vacuum tubes have been made smaller and smaller (miniature and subminiature) and associated circuit elements and assemblies have been reduced in size (subminiaturization). Still it has been felt that a much more radical step would be desirable.

It is the opinion of some of us in the electronic field that such a radical step may be possible using transistors. If transistors live up to their advance promises, and it looks as if they might, we have a device that can replace the vacuum tube in many applications and which (1) is a couple of orders of magnitude smaller than any vacuum tube, (2) should ultimately be as cheap or cheaper than the present electron tubes, (3) should be as reliable as a passive circuit element (i.e., have an almost infinite life), and (4) should require a small fraction of the power of a vacuum tube. In view of these possibilities, it seemed particularly appropriate that, at a session such as one devoted to the "Impact of Electronic Trends on Aircraft Design," the first paper should be one describing this device.

Mr. A. E. Anderson's paper, "The Transistor—An Introduction and Summary of Current Status," summarizes the present state of the transistor development art. The technical facts presented were revolutionary in their long-range significance, and it was evident that electronics may be passing over a threshold into a region where the application of electronics to aviation may be made more effective by at least an order of magnitude.

The second and third papers, "Radomes and Aircraft Design" by E. W. Schlieben and "Design Limitations on Aircraft Antenna Systems" by J. V. N. Granger, respectively, dealt with another phase of the electronic problem as it applies to aircraft. When one is attempting to couple the electronic gear in the aircraft to outside space in order to launch or to receive electromagnetic radiations, one does not have the problem entirely under one's own control. The laws of electromagnetism impose certain limits in physical size, permissible materials, and placement of devices which trespass into the field of the aeronautical engineer more directly than if only matters of weight, power, heat, etc., were to be considered.

There tends to be a broad division of electromagnetic radiators into two general classes, those that attempt to focus the bulk of the energy into a relatively sharp beam and those that are intended to be, roughly, omnidirectional. The second and third papers were devoted to one of these fields and attempted to concentrate on the broad problems rather than detailed matters of design.

As a general thing, the radome affects a certain sizable area of the surface of the aircraft, and there is a direct conflict of interest between the desires of the aeronautical and the electronic engineer. The first wants radomes to be infinitely small, faired into the surface, or sharply streamlined, while the other wants large surfaces, well out into space, and with a low "fineness"

ratio. This conflict, as well as many practical problems of design, was presented in the radome paper.

In the antenna paper, the author devoted the bulk of his time to a discussion of those antennas that are flush mounted to the aircraft or which make use of part of the aircraft structure (unfortunately with some rather definite structural modifications!) to obtain effective radiation. A point of particular interest was the change in general antenna design from wing (or tail) cap devices to flush mounted arrangements as the frequency increased from the relatively low values used for long-range communication and navigation to those customarily employed in short-range command work. Here, too, the basic elements of conflict between a pure aeronautical design and the requirements of electronic devices were clearly portrayed.

The fourth paper, "Heat-Transfer Design Problems in Aircraft Electronic Equipment," by L. Katz, dealt with a severe problem that exists while the electronic monster is in its present uncurbed state. Even if transistor elements live up to all expectations, there still will be a heat disposal problem. At the present time, however, this problem is acute and demands a great deal of serious thought. This paper dealt with a particular method of heat disposal using the principles of turbulent air flow. The method described had considerable promise and may be directly applicable to some of our more difficult and immediate heat-transfer problems.

These four papers presented to the Institute membership an interesting and representative sample of the problems that, of necessity, unite the sciences of aeronautics and electronics.

ELECTRONICS IN AVIATION—II

Problems Encountered in Today's High-Speed Flights

by

Col. J. Francis Taylor, USAF

Air Research and Development Command

The first paper on the afternoon program, "Relation of Electronics to Visual Aids," was given by Capt. J. F. Gill, Chief Pilot, Eastern Air Lines, Inc. This paper dealt primarily with the instrument approach and landing problem that, although far from being new, has certainly presented new and perhaps more complex difficulties in today's higher speed aircraft because of their characteristic higher approach and landing speeds.

The results of many actual instrument approaches made under conditions of extremely low ceilings and visibilities were discussed. These approaches were made at the Landings Aid Experimental Station, Arcadia, Calif., under the joint auspices of Department of Defense, Civil Aeronautics Corporation, and the scheduled air lines. Although all the modern electronic and visual aids were available during these tests, no one aid or no combination of aids permitted blind touch-

down and completion of the landing roll without the pilot being able to guide his aircraft by reference "outside the cockpit." On the contrary, pilots using electronic aids for final approach down to where threshold lights could be seen all noticed that the contrasting markings at the landing end of the runway (provided to show runway length in thousands of feet) was the first visual reference that could be positively identified in the landing area. These markings were in contrast to the runway color—that is, black paint on white concrete or white paint on black asphalt. Photographs taken from the cockpit during the approaches confirm the markings as the first visual fix in every low visibility approach. Captain Gill logically concluded that, since the contrast proved a reference usable for runway identification, study should be undertaken to determine the best contrasting configuration and that this be standardized for all runways. Further, a visual aids program should be started with the idea of integrating electronic aids used during final approach with visual aids so that a smooth and orderly transition can be made from instruments to contact. In this way, Captain Gill felt approaches could be made safely down to the present-day minimums even though faster approach speeds of modern aircraft have tended to increase the difficulty of landing when instrument flight conditions prevail.

The second paper, "Integrated Instrumentation for Modern Aircraft," was written and presented by Comdr. Lynn S. Beals, Jr., U.S. Navy, who is the Director, Human Engineering Division, Special Devices Center.

This paper was concerned with the inadequacy of the "bits and pieces" approach to the development of aircraft instruments. Present-day and future aircraft, in their ever increasing complexity of interrelated problems concerning control, navigation, and perhaps special military application, require the development of an instrument system rather than individually invented devices that do not consider the relationship, interpretation, or presentation of intelligence. Commander Beals described a study that proved that it required the same amount of time to train nonflight personnel as it

did pilots to fly completely by means of instruments. The only apparent reason for this strange fact is that there was little, if any, carry-over of proficiency from visual to instrument flying: what had been learned in the first situation was of little or no benefit in the second. Commander Beals reasoned that here was a good argument for a different type of display. The paper concluded with a plea for an entirely new approach on aircraft instrumentation where the basic factors to be considered would include display, the type of information the pilot needed to know, and the proper manner for the pilot to receive intelligence in the easiest interpretable manner. If this approach were followed, it was argued that safer and simpler flight would be possible because instruments, controls, the aircraft, and *man* would be working together in an integrated system.

"Storm and Clear Air Turbulence, an Analysis of the Problem and a Search for Solution" was jointly authored by Frank C. White, A.N.T.C. Division, Air Transport Association, and A. F. Merewether, Chief of Weather Services, American Airlines, Inc., and was presented by Mr. White. The paper discussed the frequency with which turbulence occurs in terms of how many miles could be flown without encountering turbulence of sufficient intensity to cause passenger apprehension or to endanger the aircraft structure. The forecasting of turbulence areas was discussed with emphasis on the difficulty of being able to forecast accurately the occurrence, location, and intensity, particularly in clear air. The air lines have established a pilot reporting system that gives a complete and up-to-date picture of the meteorological situation based on in-flight reports, weather profiles made up from the pilot's weather narrative given in his de-briefing, and Weather Bureau reports. The reports given by pilots are of particular value because of their recency. Also, due to the frequent flights of most routes, it is possible to present the forecaster with the weather changes as they occur. This is of great value in turbulence reporting and forecasting and contributes materially to the pilot's ability to plan his flight for maximum comfort and safety.

The fourth paper, "Automatic Flight Control," was written and presented by Capt. James L. Anast, All-Weather Flight Section, Flight Test Division, Wright Air Development Center. Captain Anast used as a basis for his paper the facts that the desirability for aircraft operation during all climatic and environmental conditions, the characteristics of the aircraft, and the complexities of modern military aircraft application all require controls that are demonstrably not achievable by primary human control.

The higher speeds of today's aircraft have not made automatic flight any simpler. On the contrary, our latest aircraft have accentuated a problem that was not too important heretofore. This is the problem of adjustment of the constants in the control system to permit flight, in the sea-level to 50,000-ft. range and from stalling, to speeds past the sonic barrier. It was pointed out, for example, using one present-day autopilot, that optimum adjustment for approach speed on a jet fighter results in an unsatisfactory and almost dangerous condition at cruising speed. In another case, the change from full to empty fuel tanks deteriorates the performance of the control equipment. The great range of air density and dynamic pressure changes the response characteristics of the aircraft and control effectiveness to the point where it is necessary to provide automatic adjustment of the gain setting of the control equipment as a function of static and dynamic pressure.

The control problem has been further aggravated by the use of power boost systems in some jet aircraft which have not been designed to work with automatic pilot servo equipment. For this reason, it appears that "parametric controls," as they are called, are an essential part of modern aircraft control equipment.

Other improvements mentioned were: (1) integral control in attitudes and track (or error corrector); (2) slaving of heading control to earth's magnetic field; (3) automatic barometric altitude control; (4) data smoothers, or signal filters; and (5) improvements in components such as servos, synchros, and gyroscopes.

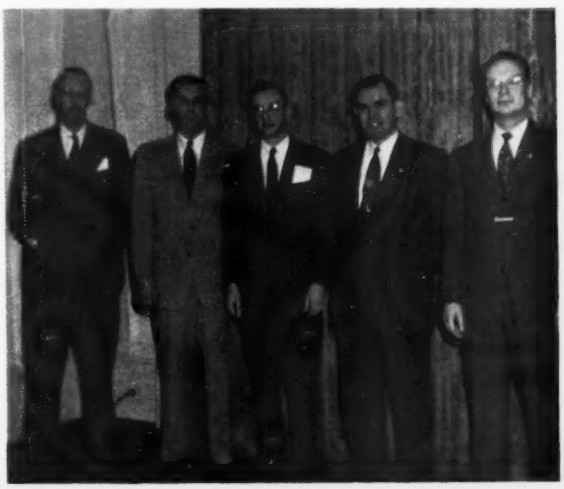
ROTATING WING AIRCRAFT

by

Bartram Kelley

Chief Helicopter Engineer, Bell Aircraft Corporation

The Contribution of Higher Mode Resonance to Helicopter Rotor Blade Bending by Harold Hirsch, Cornell Aeronautical Laboratory, Inc. Mr. Hirsch presented the results of experimental work done by the Cornell Aeronautical Laboratory for the Propeller Laboratory, WADC, Wright-Patterson Air Force Base. The three sets of experimental blades that were used had different vertical stiffnesses but were otherwise identical. One set had the normal stiffness of the blades for the Sikorsky S-51 helicopter. One set was more



flexible and the third more rigid. The investigations uncovered serious resonance conditions involving higher harmonics of blade bending in the outer part of the blade. Mr. Hirsch showed strong experimental evidence for frequencies as high as eight or nine times rotor r.p.m., giving appreciable amplitudes, owing to the proximity of the natural frequency of the third order of blade vertical bending. The source of exciting forces for these vibrations is unknown, but since we are dealing with resonance of an undamped structure, they may be extremely small in magnitude. The paper contained several excellent diagrams summarizing the results of the harmonic analysis.

Correlation of Some Longitudinal Dynamic Stability Characteristics of a Bell Helicopter from Theory and Flight Tests by Edward Seckel, Princeton University. Mr. Seckel also dealt with flight-test work previously performed at Cornell Aeronautical Laboratory, this time for the Aircraft Laboratory, WADC, Wright-Patterson Air Force Base. The paper covered serious deficiencies in conventional theory for forward flight stability of the single rotor helicopter. It was demonstrated that the theoretically predicted flight characteristics did not agree with the damped long period oscillations observed in flight test. Mr. Seckel then pointed out that he had arbitrarily tried a wide variety of different values for the various dynamic derivatives and was convinced that no set exists which would describe the observed behavior. This implies that revisions to basic theory are necessary. During the discussion several significant suggestions were made. For example, Dr. Kurt Hohenemser, McDonnell Aircraft Corporation, suggested that interference effects between the rotor and the fuselage should be included in the theory.

Performance Data and Operating Experience of a Pressure-Jet Helicopter by Igor B. Bensen, Kaman Aircraft Corporation. This paper presented the results of comprehensive tests of a pressure-jet helicopter carried out by the author when he was with the General Electric Company. The helicopter in question was the Doblhoff WN 342, brought to this country at the conclusion of World War II in Europe. Not only did Mr. Bensen's paper include interesting information on the thermodynamics of the jet cycle, duct losses, compressor efficiency, jet rotor thrust, fuel consumption, pressures and temperatures, etc., but it was also a masterful exposition of an overall engineering problem. Various general helicopter problems were described, such as blade flutter, engine cooling difficulties, ground resonance, etc. These important tests are now a matter of public record and the data are available in this comprehensive paper.

Helicopter Transmissions—Weight vs. Cost by T. J. Harriman, Bell Aircraft Corporation. This paper dealt with the broader aspects of helicopter transmissions and especially the cost of modern units. An analysis was made of the value to the helicopter operator of the weight saved by using a high precision, light transmission. The conclusion was that the industry should continue to keep the transmissions as light as possible in view of the dollar value of weight which can be saved by using hardened gears. Some studies of different configurations were presented as a further verification of the necessity for high quality gears. During the subsequent discussion, it was pointed out that any choice between different configurations, such as single or double stage spur or double planetary, depends to a large degree on the particular gear ratio required. Replying to a question concerning "looser and cheaper automotive tolerances," Mr. Harriman read off an impressive list of parts from modern high-production automatic automobile transmissions. The tolerances called for on these parts were comparable to current helicopter practice.

METEOROLOGY

by

Brig. Gen. Joseph J. George

U.S.A.F. Reserve Superintendent of Meteorology, Eastern Air Lines, Inc.

The Meteorological Session held jointly with the American Meteorological Society on Thursday morning, January 31, was about as successful as a scientific meeting can be, if one measures it by either the quantity or quality of interest displayed. The papers in this session all possessed intensely practical applications.

The first paper of the morning on Ice Protection Systems was presented by Mr. D. Frazer, National Aeronautical Establishment of Canada. The results presented were of direct interest principally in the design of aircraft and the attendant anti-icing systems. The problems of measuring icing rate, liquid water content, and drop size distribution were reviewed, and some simplified and ingenious devices were displayed for measuring some of these parameters.

One instrument of considerable interest was designed for measuring free air temperature. This has been a difficult problem for a long time and has increased in difficulty as operating speeds have increased, due to frictional and compressive effects on exposed thermometer bulbs. When icing conditions are added to the usual problems of measuring temperature, difficulties are multiplied. Although the development of the vortex thermometer undoubtedly solves to a large extent the problem of measuring accurately free air temperature, even at high speeds, it apparently is not suitable for use in icing conditions. Mr. Frazer's rough model of a cylinder, mounted closed end forward with slots surrounding that end causing a reversed circulation through the cylinder and over a thermometer bulb, appears to be an ingenious and extremely simple method that he describes as most satisfactory during icing conditions.

The point was made that the economic penalty for carrying anti-icing systems aboard aircraft is severe, and, if it is desired to protect the aircraft against 100

per cent of all icing conditions encountered, the penalty becomes so extreme as to be impracticable. Based on some 1,250 instances of icing, collected by the N.A.C.A. and the National Aeronautical Establishment of Canada, Mr. Frazer pointed out that a system that protects against 99 per cent of all icing conditions cuts the penalty greatly and is within the range of feasibility of economic design. It is fortunate that the duration of extreme icing conditions is small (it has been recently pointed out by N.A.C.A. that there is an inverse relation between intensity and duration of icing conditions).

Major C. E. Jensen, Air Weather Service, presented the Condensation Trail paper prepared by Mr. Appleman and Lt. Colonel Bundgaard of the same organization. It was apparent that a great deal of new knowledge and refinements have been added recently to our knowledge of the mechanisms of formation of condensation trails and methods of forecasting them. The two principal types of condensation trails were discussed. Those trails formed by adiabatic cooling due to passing of the aircraft (usually wing or propeller tips) through the air require a fairly moist atmosphere for their formation but are thin and nearly always of a vanishing type, consequently of little practical interest. The principal type of trail is the one that is formed by the addition of water vapor to the turbulent wake of the aircraft due to combustion processes and heat from the same source. The combustion of 1 lb. of fuel adds about 1.4 lbs. of water vapor to the turbulent wake. The balance between the heat and moisture added by the engines and the temperature and moisture of the ambient air determines when and where condensation trails will form. Charts were presented by means of which forecasts could be made, and it was interesting to note that this type of trail may form with zero humidity in the ambient air.

Not mentioned were trails formed in convectively unstable air in which the moisture added by the engine together with other parameters is insufficient to produce a trail, but the heat added causes the turbulent tube left by the wake of the aircraft to rise in the unstable air until adiabatic cooling produces a trail that is sometimes delayed considerably from the passage of the aircraft. It would have been interesting to know if this type has been found to be of no importance or if previous work in this line is considered still to be adequate.

Mr. A. C. Campbell Orde, Operations Development Director, British Overseas Airways Corporation, presented the next paper on Meteorological Problems of Jet Transport Operations. It is not often that a group of people in an industry can hear details of problems that they will face sooner or later and hear them from first-hand experience in such an operation.

When the operating speeds and altitudes are approximately doubled, B.O.A.C. has found that no really new problems are encountered, only an intensification of old ones, and a difference of emphasis is observed.

Mr. Campbell Orde pointed out that for operation of Comet I a 50 knot head wind over a course of 1,000 nautical miles resulted in an increase of direct operating costs of from 10 to 12 per cent. The point was also made that jet aircraft, in contrast to the usual reciprocating-engined air transports, must be flown at the lowest possible gross weight for any given job if economy of operation is to be attained.

Another striking comparison was the case in which a jet aircraft descends from 40,000 ft. at the end of its route and then must be diverted to an alternate. The case given resulted in a loss of 24 per cent in pay load compared to a similar loss with a Constellation 749 of only 2.5 per cent.

These figures emphasize the economic importance of accurate wind and terminal weather forecasts. The wind forecast will undoubtedly have to be of comparatively long range, say, of the order of 12 to 24 hours, while the terminal forecast will obviously require extreme accuracy for very short ranges, say, of the order of 1 to 2 hours, and for planning purposes reasonable accuracy for 12 hours.

The point was repeatedly made that actual experience with the Comet I showed wind and weather forecasts at flight levels (near 40,000 ft.) to be totally inadequate.

Few meteorologists would argue about the adequacy of such forecasts at the present time, but there are some points that should be mentioned in defense of the international meteorological fraternity. Many of the flights that B.O.A.C. has made were in tropic or semitropic latitudes where weather forecasts for any level are most difficult and where upper air observations are extremely scarce. It seems probable that far more reliable information at these levels could be had for other routes—for instance, the North Atlantic or across the United States. Operation of aircraft at 40,000 ft. is something that the average meteorological office is simply not equipped to cope with at the present time. It can be made so, but it will require an operating demand before that can happen with any efficiency. In short, it would appear that actual operating schedules of such jet aircraft will have to establish the requirement and will necessarily precede efficient organization of meteorological services for those altitudes. In this con-

nection, it should be noted that an ordinary forecast office pays little attention to levels above 20,000 ft., does not ordinarily analyze even the small supply of information received for these levels, and, when called upon to do so sporadically, the individual forecasters are in no position even to interpret what they have suddenly been called upon to analyze.

This is not to say that the inadequacies described by Mr. Campbell Orde do not exist, for they do. The point is made, however, that perhaps the situation will not require the complete renovation he infers, for there is much that can be done to extend present practices to these levels so that immediate forecasts may be improved to a satisfactory level over many routes.

An important point brought out was that about as much instrument flying was necessary at jet levels as at lower altitudes. Most of it, of course, is in cirrus clouds, but we are rapidly learning that these clouds are much more widespread and thicker vertically than we thought (1 to 2,000 ft. is common and 10,000-ft. thick clouds have been observed). Although vertical visibility apparently is still possible to some extent in cirrus clouds, horizontal visibility is extremely restricted.

It was interesting to note that in 631 hours of operation no severe turbulence was encountered in these high-level clouds. Nevertheless, other sources have reported significant turbulence in cirrus, and, at jet operating speeds, this can well develop into a real problem. It is not one that can be solved by present methods of airborne radar, since such methods depend upon echoes from precipitation which cloud particles do not return. The interesting problem of clear air turbulence was not mentioned, presumably because it has not been encountered in the short operating experience of Comet I.

It was clear, however, that meteorological services all over the world will have to speed up their processes and become more decisive and accurate by every means at their command if jet aircraft are to be operated economically in air transportation. As a corollary, it appears inescapable that jet operating companies can do much to help themselves by learning to make optimum use of weather information presently available.

The final paper of the morning session on Clear Air Turbulence was given by Mr. C. P. Mook, U.S. Weather Bureau, Washington National Airport. Obviously, in a fairly early stage of both gathering data and analysis, the intense interest that jet operations have produced in high-level clear air turbulence made this subject of great interest.

Past investigations in the subject, both in England and the United States, have indicated that clear air turbulence is found in proximity to the jet streams and by implication in regions of strong horizontal wind shear.

Mr. Mook, with considerable data at his disposal, analyzed a number of moderate or severe occurrences chosen so that an adjacent wind sounding in both time and space was available. In every instance, he was able to find a high vertical wind shear close to the altitude at which turbulence was encountered. It was interesting to note that consideration is being given to refinements in reporting upper wind so that these shear zones will not be omitted from regular reports as may happen at present. It was not clear whether horizontal shear was also present in these cases.

The importance of clear air turbulence at high levels, of course, stems from the fact that, at the high speeds of jet aircraft operation, the same amount of turbulence which produces accelerations less than a given design load at lower speeds may possibly exceed design loads at the higher speeds. Furthermore, turbulence in clouds is definitely associated with amount of precipitation and, consequently, can be avoided in a large part by air-borne radar, while clear air turbulence is not amenable to treatment in this fashion.

AIR TRANSPORT SAFETY

by

Jerome Lederer

Director, The Daniel and Florence Guggenheim Aviation Safety Center at Cornell University

The comments, questions and discussions evoked during the Air Transport Safety Session are indicative of the interest in, and the caliber of papers presented on, this timely subject. Since all three of the papers presented by Messrs. Berman, King, and Moss are scheduled for early publication in the REVIEW, a record of the discussions by some of the experts in the audience seems appropriate here. (*The paper by Captain Moss may be found elsewhere in this issue*—Ed.)

Dr. Edward P. Warner*—"First, I should like to compliment the speakers on the candor, quality, and quantity of the information and ideas that they have brought out. As to statistics on accidents, placing the blame on Pilot Error is a confession of defeat—it is a dead end. When there is an error, there is a cause. The purpose of accident investigation is to avoid having another accident, not to place blame. Pilot Error as such is not correctible.

"To attribute an accident to 'Pilot Error' and let it go at that is like attributing it to 'engine failure' and saying nothing more. We cannot prevent the recurrence of engine failure unless we know why the engine failed to address the corrective or preventive measures to that specific cause. The same is true of pilot failure.

"Pilot failure may be due to inherent unfitness, to inadequate training, or to the conditions under which the pilot is working at the time of the accident, including the difficulty of the problem that the attendant conditions present to him. Pilot failure might then be avoided by more careful selection of pilots or more careful rechecking of their continued fitness; by better and more extensive training; or by improving the conditions under which the pilot works and reducing the difficulty of the problems that he has to solve. I do not think we can expect that much can be done by initial selection to get men materially better than those who

* Council President of I.C.A.O.

now constitute the piloting profession. Methods of checking continued fitness may be improved; certainly there can be improvements in training, especially through a much larger use of simulators; but I think we shall continue to find that most of the accidents attributed to pilot error could not have been overcome by any reasonably practical improvements in selection or training and must therefore be attributed to the conditions under which the pilot had to work at the time of the accident and to the difficulty of the problem that he had to solve. It is in the simplification of the problem, by improvement of navigational aids and otherwise, that our best hope of accident reduction lies.

"We need not more regulations, but more imagination to foresee and prevent the combination of circumstances that will produce an accident. Safety organizations have their place, but if everyone else relaxes and thinks that it is up to the Safety Organization to find the answers, the value will be negative. One of the main functions of such an organization should be to stimulate others to look for trouble. The same capacity of knowledge, detective skill, and imagination which is now used to determine the cause of an accident should be applied beforehand to foresee it and so to prevent it. This, plus the spurring of others—mechanics, pilots, flight engineers—to look for causes of trouble, to ask themselves constantly 'What if ——?' should be playing a more prominent part in accident prevention.

"Pilot Error as an accident cause is a legal label rather than a technical one. Almost every accident involves the interaction of a larger number of human, material, and natural factors. For our real purpose of avoiding accident recurrence, the factor that interests us is the one that could most easily have been changed in such a way that the accident wouldn't have occurred, and that is the one that ought to be specified as the cause. It generally proves that it would have changed one or more of the material factors involved in the occurrence of the accident than to have changed the human ones."

Question—"Can the pilots be expected to follow the certification 'numbers' such as V_1, V_2 and all the numerical requirements regarding take-off weights for varying conditions?"

Captain W. W. Moss*—"The 'numbers' are not representative of actuality. 'Numbers' are developed under ideal conditions that seldom exist."

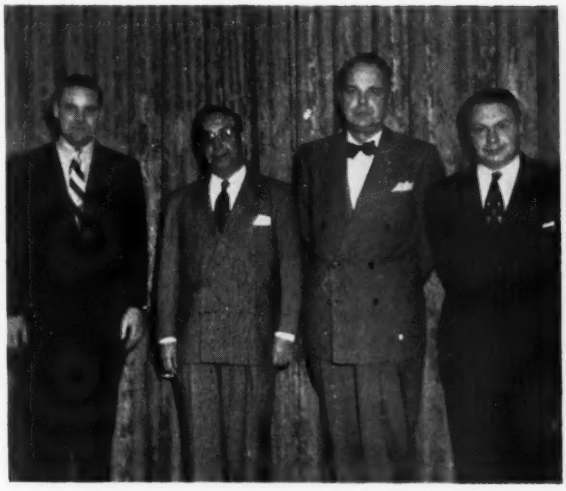
Dr. L. A. Shepperd†—"How many airplanes have just missed being involved in an accident with no knowledge to those who could do something to avoid the repetition that ultimately leads to an accident? Should there not be greater emphasis on reporting near misses? An appropriate slogan would be '*Report and study today's near misses and thus prevent tomorrow's accidents.*'"

Mr. William I. Steiglitz‡—"I heartily endorse Dr. Warner's remarks. No safety organization can check everything itself. It would be impractical to attempt it.

* Pan-American World Airways, Inc.

† Columbia-Presbyterian Hospital.

‡ Design Safety Engineer, Republic Aviation Corporation.



The safety organization acts as a focal point to spearhead and push safety in design. Otherwise, safety is likely to fall by the wayside because of strong pressures on designers by economics, production requirements, and delivery requirements. Safety engineers must be able to bring safety problems before top management for decision.

"One of Mr. Berman's points should be explored a bit further, since it serves as a good example of the need for *flexibility* in standards to make possible a redesign, compromising *other* design characteristics if greater safety could be achieved. Mr. Berman points out that the lack of sufficient foresight in not designing a fuel tank cap and cover that would be operationally fool-proof was responsible for a series of fires and explosions. What Mr. Berman says is correct, but the reason for adhering to this design was because the manufacturer must conform to standards established by the Air Force. The designer has been using the fuel design caps that the Air Force specifies. Several attempts to redesign the caps to minimize faults in one form or another have been turned down, even though the redesign was superior with regard to fire hazard. (One cap was turned down because a screw driver would have to be used to remove it. Another design was turned down because ice might freeze the cap to the filler neck.) In the meantime, aircraft continued to have fires and explosions."

Dr. T. P. Wright**—"In regard to the Independent Air Safety Board suggested by Captain Moss—while I am not particularly opposed to it, I have never been able to justify it on the basis of the good record of the year 1939, because the accident trend has improved over the years despite a great increase in traffic.

"It was a shame that the terrain clearance indicator was given a bad name prematurely. With what is known now, it should be well worth trying it again.

"On the matter of survival in a crash, the Convair has had a very good record because apparently the design of seats and belts is more than the regulations require.

** Vice-President for Research, Cornell University.

"Captain Moss mentions that one in nine pilots would be involved in a fatal accident in a flying lifetime of 30 years. To be fair in evaluating risk, this should be compared with the ordinary hazards of living. Based on deaths to pilots in scheduled air-line passenger service in 1951, it would seem that the pilot hazard is about two and one-half times greater than the ordinary hazards of living.

"Dr. King's paper refers to impact injuries. Shoulder harness should be part of any study on safety and should be required by regulation in light planes. The owner may have the right to decide whether he wants to use it. This is good old American philosophy. If a man wants to take a risk, let him do so provided he hurts no one else, but the harness and fastenings should be available if he wants to use them. Statistics would indicate that 50 per cent of the fatal injuries might be prevented by well designed shoulder harness."

Captain Moss—"In connection with Dr. King's reference to the need for functional cockpit design, I noticed in one air transport that I thought had the best cockpit of any airplane, that the flight engineer did not use the safety belt. The reason was that when the belt was fastened the engineer was unable to reach all his controls!"

Mr. W. Littlewood* (by letter)—"I was very much impressed with the excellence of Captain Moss' paper that, as its title implies, dealt with safety from the pilot's viewpoint. I, of course, can have no objection to that viewpoint, as it obviously involves directly the safety of the passengers and the preservation of the equipment, but such an approach inevitably leads to some change in emphasis.

"I must take exception to Captain Moss' emphasis on the need for longer 'debugging' periods during which planes would not be flown in regular passenger service. I am sure we all are seeking the same end, which is the utmost reduction of air transport accidents, and the only reason I object to his approach is that I believe the objective can be much better attained by a method other than he suggests.

"I think he proved my case rather conclusively by the curves that he presented showing accidents per 100 million plane miles versus 100 millions of plane miles for the DC-3, the DC-4, and the DC-6. If you will compare these curves, you will note that the DC-3 had reached *300,000,000 plane miles* before it showed the same accident rate as the DC-4 and the DC-6 *brand new*. If, for the sake of argument, we assume that the DC-3's averaged 200 m.p.h.—a liberal figure—they would have flown *1,500,000* hours before they achieved the same accident rate as the DC-4 and DC-6 when new. At 3,000 hours per year, that would be the equivalent of 500 plane years or 500 planes operated for a year or one plane operated for 500 years—all of which appear rather impractical as a 'debugging' program!

"Captain Moss' curves certainly don't prove his contention, but they do seem to prove that airplanes built in the early and late 1940's started out just that much better than airplanes first built in 1936. The improvement could be attributed to better materials, construction, accessories, instruments, and engineering in the airplane, as well as a substantial improvement in operating and airway aids, etc.

"The way to approach this problem, I am sure, is not by the method of subjecting new airplanes to a prolonged unscientific but expensive casual operation, but to subject them, before any operation, to a most intensive, intelligent, and thorough accelerated 'debugging' inspection and flight-test program. It can almost be guaranteed that such a program, conducted under impartial, intelligent, and energetic supervision, and with the intention to discover, disclose, and correct all ascertainable deficiencies in advance, will eliminate many more potential causes of trouble than we could hope to uncover in any prolonged, casual operation, whether it be in cargo or other service."

Question—"Has any study been made of what the pilot is required to see when flying, and have the results of the study been related to design criteria?"

Dr. Barry G. King†—"We have been concerned with the medical phase of the problem—that of describing what man could see if he were sitting out in space with no opaque objects to interfere with his view. Pigman and Edwards of the C.A.A. Indianapolis Laboratories have recently reported on an extensive investigation of what a pilot is required to see while flying. They are continuing their studies."

Question—"You have presented measurements as a basis for locating aircraft controls; have you measured the forces that should or could be used in their operation? Has anyone else measured them?"

Dr. King—"There are numerous investigators who have reported some limited data on strength used in the operation of the controls. These investigators include members of the N.A.C.A. I believe it was Mel Gough who was responsible for some of the tests. Other investigations include some tests on two subjects by the Civil Aeronautics Board; the intensive studies of Lombard on control of the forces; and the studies by Orlansky. Further, the Special Devices Division of the Office of Naval Research has published some data on strength measurements. There has, however, been no orderly investigation of man's ability to operate controls at various points in space. We started the study at the Civil Aeronautics Laboratories in Oklahoma City approximately a year and one-half ago. These studies are continuing and will concern strength and endurance in the operation of the control in relation to its cockpit position and to the biomechanical advantage (or disadvantage) at which it can be operated by the pilot."

* Vice-President, Engineering, American Airlines System.

† Research Executive, Medical Division, C.A.A.

ROCKET PROPULSION

by

C. W. Chillson

Propeller Division, Curtiss-Wright Corporation

The joint session on rocket propulsion was held on the morning of February 1 as a part of the I.A.S. Annual Meeting and, in accordance with the custom of the Institute, was chairmanned by your reporter as American Rocket Society President. A high degree of interest in rockets was indicated by an excellent attendance of over 360. The three papers presented dealt with some of the broader aspects of rocket propulsion, since it was felt that the audience would be more interested in such topics than in detail rocket-design considerations.

The first paper, "Range Formulas for Rocket-Powered Aircraft," by R. W. Allen compared an aircraft with an air-breathing engine following a Breguet path (constant lift to drag ratio, constant velocity, and thrust equal to drag) with two types of rocket-powered paths. The constant thrust rocket-powered system was found always to give less range than the air-breathing engine. However, a rocket-powered airplane with a constant thrust phase followed by a glide path was found to have ranges potentially greater than those of the air-breathing engine under certain circumstances. Mr. Allen's formulas assumed the initial and final airplane velocities to be equal, with the initial velocity being provided by some sort of boost. The major factors in obtaining long ranges with the glide rocket airplane are:

(1) By flying at higher altitudes, it can maintain a higher velocity without increasing drag.

(2) Its range increases approximately with the square of the specific impulse, whereas the Breguet path increases only linearly.

(3) Increasing mass ratios increase the range at a greater rate than the Breguet range.

(4) It may have a higher average velocity that contributes to greater range, since it is not constrained to maintain a constant average velocity as required by the Breguet range formula.

The second paper, "Large-Scale Production and Handling of Liquid Hydrogen," by H. L. Coplen, Senior Engineer, Aerojet Engineering Corporation, described in considerable detail a project undertaken with the assistance of Dr. H. L. Johnston of The Ohio State University Research Foundation, who acted as a consultant, to design and operate a continuous liquid hydrogen-producing plant. Over a period of approximately 6 months, some 7,400 lbs. of liquid hydrogen were produced. A schematic flow diagram, as well as pictures of the installation and drawings of critical elements, was included with descriptions of some of the special requirements and particular precautions necessary to produce this liquid that boils at only 34° F. above absolute zero. Based on the experience gained with this unit, a larger unit was designed with a capacity of approximately 3,000 lbs. per day. While the first unit employed a high-pressure system (approximately 2,000 p.s.i.g.) and obtained cooling by the Joule-Thomson effect as the hydrogen was expanded through throttling valves, it was found desirable in the larger unit to specify a low pressure (approximately 220 p.s.i.g.) closed-cycle helium refrigeration system employing three turbo expanders to extract work from the refrigerant at steadily decreasing temperature levels. This refrigeration system would be used to condense gaseous hydrogen at nearly atmospheric pressure. In addition to discussing the production phase, Mr. Coplen covered requirements for storage and handling, including reference to the materials of construction, insulation, and analysis of storage losses including those associated with the exothermic ortho-para conversion of hydrogen. He also commented on safety precautions, which he indicated on the whole to be less rigorous for liquid hydrogen than for high-pressure gaseous hydrogen. This paper was refreshingly free from security deletions and gave an exceptionally complete picture of the problems associated with liquid hydrogen production and handling. Since hydrogen is in many respects the ideal rocket fuel, these advances in liquid hydrogen technology are of immense potential practical importance to the rocket industry.

The final paper, "The Role of Research in Rocket Development," by Dr. Paul F. Winternitz, Director of Research, Reaction Motors, Inc., traced the history of contributions by research to the rocket field and took a long-range look at future problems, enumerating the fields of research potentially involved. Dr. Winternitz postulated as the "ultimate problem" the expansion of inhabitable space. Since the rocket is the only power plant capable of transporting man and his effects to other planets or to man-made satellites, both the rocket research worker and engineer should consider this as a final objective. Dr. Winternitz emphasized the delays in the transmission of fundamental knowledge from the research worker to the engineer stating that "This is . . . for progress, the rate determining step. . . . In fact, quite efficient rockets might have been built with the knowledge available 50 years ago." The solution of future problems will require both fundamental and applied research, each organized along its most productive lines. Strong individualists working with a limited number of trusted assistants unhampered by administrative detail will usually produce the new ideas, while large, well-organized teams with extensive facilities are most effective in applied research. "In both types of research the whole gamut of our knowledge is used, from astrophysics and meteorology to physiology and biology." It is clear that Dr. Winternitz expects research to play an ever increasingly important role in the development of rockets of the future. The goals are certainly among the most challenging in our times.

It is impossible to do even passing justice to the papers in this brief space. Those of you who are inter-

ested and who could not attend the meeting can obtain preprints of any or all papers from the American Rocket Society's Secretary.

FLIGHT PROPULSION

by

S. T. Robinson

Sanderson & Porter

The Flight Propulsion Session of the Twentieth Annual Meeting of the I.A.S. was devoted to the subject of Turbo-Prop Propulsion. This subject was chosen because it was believed to be the most controversial subject in the turbine power-plant field and one requiring immediate effort toward solution in order to have a well-rounded Air Force and commercial air-line system.

The opening paper was presented by Mr. Raymond Young, President, Reaction Motors, and Chairman of the Panel on Aircraft Propulsion Systems for the Research and Development Board, and Edward Glodeck, Deputy Director of the Committee on Aeronautics, Research and Development Board. It was indeed unfortunate that security restrictions prevented these authors, who jointly are better acquainted with this subject than anyone else in the country, from presenting a complete picture of the status of this development. However, even working under a handicap, a well-rounded paper covering the status and current capabilities of turbine-propeller propulsion systems was presented. The key to future development of the turboprop engine vs. the turbojet was presented graphically, reproduced here as Fig. 1. This curve is a plot of specific output vs. specific fuel consumption, plotted for a high-altitude, high-speed condition for a high-compression ratio engine in which the turbine inlet temperature is the variable. It will be seen that all advantages of high inlet temperature accrue to the turboprop engine.

The authors concluded their paper with a tabulation of both British and American turboprop engines and

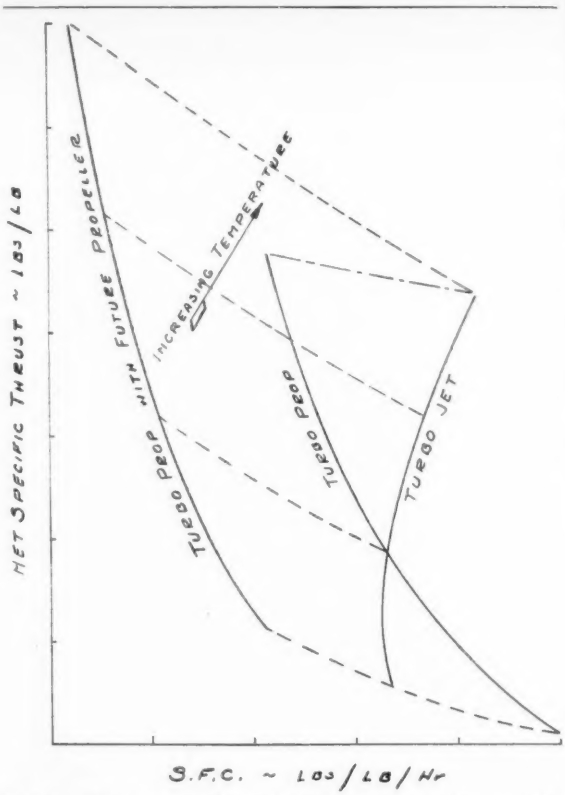


FIG. 1. High compression ratio turboprop vs. turbojet at high subsonic speed and 35,000 ft. altitude.

turboprop-powered military and commercial aircraft. The effort the British are putting into this development in contrast to our own was apparent. This was particularly so in the tabulation of engines, which, while the list was not lacking in quantity, showed but two basic engines of American origin in an operational status, the rest being either available to American engine manufacturers through license agreements or of a size too small to be of value for military or commercial aircraft of the size under discussion.

Mr. George Brady, Director of Engineering, Propeller Division, Curtiss-Wright Corporation, presented the second paper on "The high-speed propeller." Mr. Brady's paper was extemporaneous and based on his excellent paper presented at the Third Anglo-American Aeronautical Conference in 1951. Mr. Brady covered the development of the high-speed propeller over the past 5 years including subsonic, transonic, and supersonic blading. The structural problems associated with high-speed propellers were discussed, with particular emphasis on stresses arising from forced and resonate vibrations. Governing was touched on as well as the problems of the emergency characteristics of the control system. This latter item is one requiring extensive development, regardless of the type of blading used, for engines being developed in this country. The coupled turboprop engine compressor is capable of absorbing large amounts of energy from any source available to turn the shaft. During flight, in the event

of a power failure, the engine compressor is driven at high power levels by the windmilling propeller, the energy required being derived from the forward speed of the airplane with a resulting drag. In a multiengined aircraft, this results in an assymetrical thrust that seriously affects the control of the aircraft. Two solutions to this problem seem to be available—a feathering control receiving a signal from shaft torque or a decoupling system whereby the propeller is decoupled from the shaft at zero or negative torque. Neither of these systems results in zero drag of the propeller, although it is reduced to a value that may not be objectionable.

To return to the propeller-blade performance and configuration, which are pertinent items to the subject of the session, two figures are reproduced in Fig. 2 giving the comparative efficiency at high speed of the transonic and supersonic propeller together with the relative size of these two types of propellers for the same power.

The final paper was presented by Mr. William Fox, Project Engineer, Consolidated Vultee Aircraft Corporation. With Convair having had by far the majority of turboprop flight experience in this country, and Mr. Fox having spent 8 years in experimental flight-test work with a greater part being on turboprop aircraft, the author is well qualified to discuss "The Turbo-Prop Airplane," the subject of his paper.

In his paper, Mr. Fox outlined the history of the turboprop airplane as it has been developed in this country and then discussed the detailed operating problems, principally as encountered in the XP5Y-1 airplane. The major problems encountered have been approach thrust, assymetrical thrust, engine failure, and engine and control system maintenance.

Due to the low propeller-blade angle required to accommodate the high idle speed of the turbine and the fact that the thrust vs. air-speed curve for constant blade-angle operation is extremely steep, large changes in thrust occur during a landing approach which result in ballooning or a floating tendency in the airplane. It appears that fuel flow causes the greatest departure from a desired schedule due to metering tolerances and the grade of fuel being used. One thing that is required is a fuel metering system insensitive to changes in viscosity between grades of fuel. Assymetrical thrust during landing or stall approaches has been annoying. Variations of thrust between engines is caused by differences in speed, fuel flow, and propeller pitch setting, all subject to accuracy of manufacture of the device in question. Here again, fuel flow has been found to be

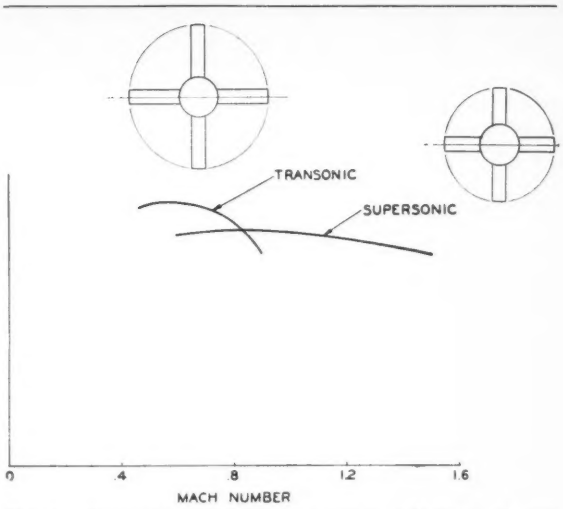


FIG. 2. Comparative efficiency and size at high speed of transonic and supersonic propeller.

the major offender. Engine failure, however, has been found to create the most dangerous flight situation, particularly if it occurs during take-off or landing. Engine failure results in a high drag of the windmilling propeller which can result in a loss of longitudinal control in single-engined installations and directional and lateral control in multiengined installations. This high drag encountered at engine failure is due to the high motoring power requirements of the compressor of the coupled engine and the extremely low propeller-blade angle used for engine idle conditions. Automatic feathering or automatic decoupling as discussed previously by Mr. Brady offer solution to this problem.

One cannot help but feel that we have traded the simplicity of the coupled engine for an extremely complex fuel flow and propeller-control system. Whether an engine with a separate power turbine would offer a solution to these problems with simpler control systems, without presenting other problems of equal magnitude unique to the arrangement, can be determined only by comparison of the engines under equivalent operating conditions.

Mr. Fox concluded by stating that the operation of the turboprop engine is really simple when all of the components function properly, and he was of the opinion that continued research and development would provide a power plant that would far exceed the capabilities of the reciprocating engine and for some specific applications, the turbojet.

The Air-Line Pilots Look at Safety

CAPT. WILLIAM W. MOSS*

Air Line Pilots Association

Introduction

SAFETY OF AIR-LINE TRANSPORTATION is important in a great many ways, the most important of which is the moral responsibility to the traveling public. In this paper, however, a narrower and more personal point of view will be examined—that of the active air-line pilots.

Safety to a pilot is extremely important in a personal sense. As the "man out front," he is vitally concerned with his own survival as well as with his primary assigned responsibility for the safety of his passengers and crew. He is also vitally affected by the impact of safety on his own air line particularly and the industry in general. His employment security, his opportunities for promotion, his pay, his choice of domicile, and his working conditions in general are all affected by the impact of the level of safety on the public's demand for air transportation. The effect of accidents is hard to judge, but the following is typical.

On a flight the day after a well publicized nonscheduled crash recently, the author had the opportunity to talk extensively with the small number of passengers aboard. During the conversations, it developed that a significant percentage was nervous about the flight, and several mentioned that they had almost canceled their reservations in favor of going by boat. How many of the empty seats were due to this cause is hard to determine, but Lederer[1] has said:

"The traffic department of another large airline, after studying its variation of traffic with accidents, concludes that the effects of a well publicized accident or series of accidents are felt for about two months. It results in an average loss of 10% in passenger revenue during this period. This loss, at present levels of traffic, would amount to $1,700,000 for this one airline."

This form of measurement, however, touches only the effect on those who already travel by air. It takes little or no account of the potential air travelers who, because of fear, have never set foot in an airplane. It is a reasonable guess that the horizons of air transportation could be broadened considerably by a marked improvement in the safety record.

The Past and Present

In assessing safety, it is necessary to know where we are and where we have been. Fig. 1 shows this. The author has chosen the parameters of plane miles and accidents rather than the usual ones of passenger fatalities per passenger mile because these are more representative of the pilot's point of view. He flies many thousands of miles per year, and, from his personal safety angle, it matters little if there are 1 or 100 passengers riding behind him. He is particularly interested, however, in what is likely to happen during the millions of miles he will fly during his career.

Fig. 1 is a plot of accidents and fatal accidents per 100,000,000 plane miles for all flying by U.S. scheduled domestic and international air lines for the years 1938–1950. All figures are taken from Civil Aeronautics Board records and the Board's definition of an accident ("involving serious injury to persons and/or substantial damage to the aircraft") was used with no screening. The mileage for all types of flying—revenue, nonrevenue, charter, ferry, test, and training—was used, for it is obvious that the pilots were exposed to all types.

The most obvious conclusion to be drawn is that the record of both types of accidents has improved tremendously over the years, with accidents dropping from a rate of 48 to 10, and fatal accidents from approximately 8 to 1.5. This is indeed improvement.

In following the trend of the curves, several points are of significance. First is the rapid improvement in the years 1938–1942. The pilots attribute this primarily to the influence of the Independent Air Safety Board. There were, of course, other factors involved, notably the wide introduction of the DC-3, but it is the pilots' opinion that a large share of this improvement was due to the many reforms and aggressive actions of the Air Safety Board during its brief life. While it is not the purpose of this paper to indulge in the controversy that has raged for years around this board, it appears desir-

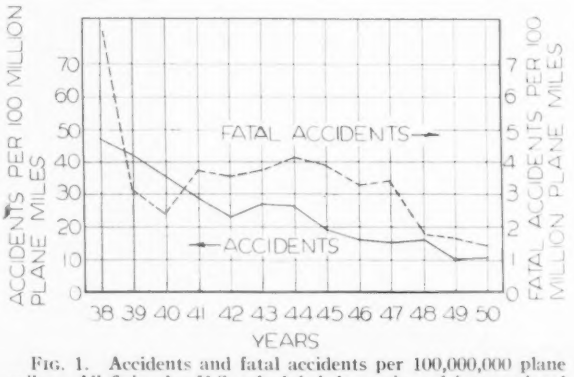


FIG. 1. Accidents and fatal accidents per 100,000,000 plane miles. All flying by U.S. scheduled domestic and international carriers. Source: CAB.

Presented at the Air Transport—Safety Session, Twentieth Annual Meeting, I.A.S., New York, January 28–31, February 1, 1952.

* Captain, Atlantic Division, Pan American World Airways, Inc.

able to comment in passing that the pilots still believe in the principle of independence involved, even though we feel that the present CAB Safety Bureau is doing a good job. We feel that if a board composed of experts has the power of enforcement, rather than having its recommendations and policy tempered by a higher authority of nontechnical membership, greater safety progress would result with marked benefit to the industry.

The second period of interest in Fig. 1 is the war years, 1943–1945, in which, while accidents declined slightly, fatal accidents continued at a high level. This we attribute to inexperienced personnel, both flight and ground, and to the general insecurity and pressure of that period.

The third period, 1946–1950, is that of the introduction of postwar equipment, notably the wide use of four-engine planes for both domestic and international travel. This period is marked by a decrease in both rates, particularly the fatal one, followed by a definite level-off. Preliminary figures for 1951 confirm this stabilization, showing even a slight increase in both rates, particularly the fatal one.

One point of great significance to the pilots and one not generally appreciated is this: At the 1949–1951 rate of accidents and present airplane speeds, the chances are 3 out of 4 that an air-line pilot will be involved in an accident during his career.* Likewise, the chances of his being involved in a fatal accident are about 1 in 9. Looking at this, we feel that, although great strides have been made in the past, improvement is necessary and due. We feel that the past improvement was made from an extremely high rate and that the industry should not be satisfied with the present status quo.

In any analysis of accidents, it is customary to place the blame for from 45 to 50 per cent of the accidents on the pilot. We feel that while, of course, many errors of omission and commission are made by pilots, being only human, there are other underlying factors, and in the remainder of this paper an attempt is made to point out areas in which some of these factors can be eliminated.

In support of this contention, a situation that developed at the Naval Air Station, Honolulu, during the war is of interest. The main seaplane operating runways were to the northeast and east, crossing at a point approximately 1,000 ft. from their origins. Lighting was furnished by permanent lights on poles some 6 to 10 ft. above water level. About two months after the commencement of operations, during a night take-off, a Navy pilot tore the bottom out of a PBM on the coral reef beyond the intersection of the two runways. The verdict was "pilot error," a finding concurred in tacitly, at least, by the majority of pilots flying in and out of the area. About a month later, a commercial air-line pilot did the same thing with a PB2Y. The plane rested on the reef most of that day and was removed just before sunset. Before sunrise there was another PB2Y on the reef within 50 yards of where the first had been.

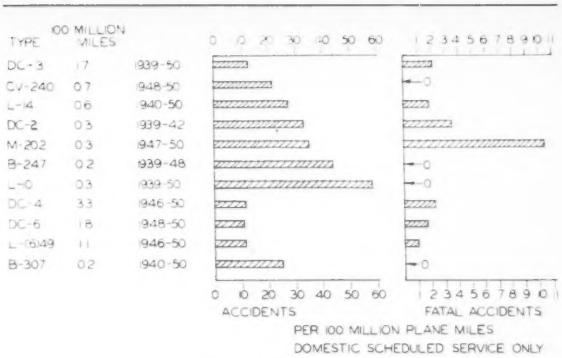


FIG. 2. A comparison of the accident rates of widely used U.S. transport aircraft. Source: CAB.

Now, each of those accidents, by itself, could be attributed to "pilot error." However, with an accident pattern established, it seemed likely that there was a contributing factor. Investigation showed that the errors of runway alignment were due to the confusion of the runway lights, on their poles at a considerable height, with the lights of Honolulu in the background. The lighting system was then modified to reduce this confusion, and it is significant that there were no more similar accidents.

DESIGN

Furthering this principle of outside influence as a cause of "pilot error," it would appear that the airplane design should have an effect. McFarland[2] has said:

"The fact that accident rates vary from model to model suggests that the airplane itself may play as important a role as the human element. . . . It is commonly believed that certain air transports are generally safer to operate than others. The evaluation of such a statement is almost impossible because of the many variables involved or the lack of a common base line of comparison."

Since this statement was made, statistics have only recently become available through the CAB which make it possible to attempt such an analysis. These are presented in Fig. 2. The figures presented here apply only to scheduled flying by U. S. domestic air lines, the international figures not being available. Although there are many factors involved, it is felt that the variables of crew competence, maintenance, and operational techniques are largely eliminated through the close CAA supervision and regulation of the scheduled air lines.

In analyzing the data, it is significant in the case of the twin-engined planes to note the marked correlation between the accident rate and the accumulated mileage and the lack of correlation between the accident rate and the period of years over which the planes flew. This leads to the conclusion that it is the original design and its development as accumulated mileage shows up weak points which determine the safety level, rather than the skill of the pilots. If the latter were a major deter-

* Nine hundred hours per year for 30 years at 275 m.p.h.

mining factor, there should be some correlation of years of service with the accident rate. It is a fact, however, that piloting technique soon becomes stabilized on each type of plane and varies but little over the years, and the pilots quickly become proficient in it.

In looking at the fatal accident rates, it is noteworthy that there are four types with perfect safety records. Most significant of these is the CV-240, although the accumulated mileage of the other three is sufficient to take their combined record out of the realm of pure chance. By all averages, the CV-240 should have had three fatal accidents.* In fact, it has had six serious accidents, but in all the survival rate has been 100 per cent. This suggests strongly that there are factors inherent in the design which account for this remarkable record. A complete examination into these factors would appear to be one of great potential industry benefit; however, it is out of the scope of this paper. In passing, though, the suggestion is made that the slow spread of after-crash fire is one of the major survival reasons.

In looking at the modern four-engined planes, the uniformity of their accident rate suggests the influence of CAR 04 with its detailed performance and design requirements. It would appear that, although each plane has its individual characteristics, the overall level of safety is about the same, bounded as it is by the parameters of 04. This influence of regulation on the safety level will be covered later.

If we accept the principle of the marked effect of design on the safety record, and, by inference at least, its effect on "pilot error" accidents, what are some areas that warrant attention? Two suggestions will be made.

Over the 13-year period of this study, there have been some 47 accidents due to misuse of the landing gear, either retracting it when on the ground or landing with the gear not down and locked. While these accidents are not fatal ones, they are expensive, both with respect to damage to equipment and to loss of utilization. In one recent case, the president of the air line has been quoted as calling it a "million-dollar mistake." Obviously, the pilots do not cause these accidents on purpose, and, since there is a definite pattern established by these, there must be a basis for confusion of controls within the cockpit. What can be done to make it impossible for these accidents to happen? Already we have various solenoid pin arrangements whose purpose is to prevent the inadvertent retraction of the gear on the ground, but by this time they are obviously proved to be not 100 per cent effective. It is equally obvious that the landing gear warning horn does not deter people from landing with the gear neatly retracted. Howard[3] has proposed a system that involves "shoe strings and rubber bands"—the "shoe strings" to tie component controls together so that it will be necessary to make two consecutive mistakes with different controls to cause an accident and the "rubber bands" the by-pass arrangement so that it will be possible to actuate controls out of the normal sequence if necessary, such as during a "go-around."

Basically, his system involves the interconnection of landing gear and flap levers so that it would be impossible to put down more than take-off flap unless the gear were down and also would make it impossible to raise the gear when more than take-off flaps were extended. It would also be impossible to raise the flaps above the take-off position after take-off unless the gear were up. This interdependence would accomplish this: (1) In order to land without the gear down, it would be necessary to forget *both* the gear and the flaps, an unlikely coincidence. In Howard's estimate, this coincidence would occur only once every 196,000,000 landings—about 150 years of domestic air-line operation. (2) It would be impossible to raise the gear on the ground, thinking that it was the flaps that were being raised. (3) It would be impossible to raise the flaps immediately after breaking ground on take-off instead of the gear, an extremely dangerous procedure with present high wing loadings.

In addition to this interconnection, he would interconnect the flaps and throttles, much as is now done with the throttles and flight-control lock, to prevent a take-off with flaps up. That this is an important point is attested by the author's personal experience of having made such a take-off in a DC-4, in spite of an unhurried reading of the check list with both another Captain and a Flight Engineer in the cockpit and participating. Luckily there was ample runway available, but, under conditions of minimum field length with the high wing loadings now used, such a take-off could easily be catastrophic.

By putting into practice some such ideas, it should be possible to eliminate 7.5 per cent of all accidents and 12.5 per cent of those attributed to "pilot error," as well as eliminate the exposure to the no-flap take-off hazard.

The second idea presented here is one in which the pilots have considerable faith—the mandatory use of reverse pitch propellers on all air-line aircraft. In the period studied there have been some 62 accidents in which the aircraft has run beyond the field boundary, either as the result of an aborted take-off or, more frequently, after landing. Since the introduction of reversing propellers, no aircraft equipped with them has been involved in such an accident, with one exception. In that case, the use of reverse pitch prevented a far more serious, and probably fatal, accident. We feel that they should become a required item of equipment, much as the full feathering propellers became a decade ago. Their use, in our estimation, would prevent 10 per cent of all accidents and 21 per cent of "pilot error" accidents.

Since the pilot is the final determinant of flight safety, his help should, we feel, be actively sought in the early design stages in order to make his tasks simpler. This is occasionally being practiced but not nearly to the

* One hundred sixty-five million miles (to December, 1951) × 1.76 fatal accidents per 100 million miles (all plane average 1948–1950) = 2.9 fatal accidents.

extent we feel desirable. Raymond,[4] in his excellent 39th Wilbur Wright Memorial Lecture, said, in speaking of the time of a new design's first flight:

"Here also enters, too often for the first time, the human equation in the form of the pilot and crew. There is an increasing awareness of the fact that the experience and point of view of operating personnel should be intimately joined with that of the designer from the beginning."

A leading manufacturer, in a personal communication to the author, wrote, in discussing the contributions made by active air-line pilots to the success of the design in question:

"The question of why there was success here and not elsewhere seems to be answered by the timing factor. This program was set up at a very early date in the development thus allowing enough time to thoroughly discuss differences of opinion and reduce them to an objective common denominator."

We wish the thoughts expressed above were more widely practiced within the industry.

In passing, it might be well to note that the Air Line Pilots Association is carrying on an active campaign of familiarization with the problems of design and operation of turbine-powered transports in anticipation of their early commercial application, and we would welcome the opportunity to contribute to their safe and efficient development.

Operations

Given an initially sound design, the next and extremely important step in making it a safe plane to fly is the "debugging" of it under actual operations. Contrary to popular opinion, this process does not end with the first few years in service but extends throughout the total operating life. Fig. 3 shows this clearly. Though the initial four or five hundred million miles are probably the most important, the DC-3's long history shows a continuous gradual improvement beyond that point. This initial rapid improvement is also clearly shown by the DC-4 and -6 curves, evidence of the excellent joint efforts of the manufacturer and operators. If their future development parallels that of their predecessor and if other current transport types are improved at the same high rate as has been shown for these types, we indeed have promise of a marked improvement in the overall accident rate.

Incidentally, in the preparation of this figure, it was not meant to slight other types. The aircraft plotted were chosen because their accumulated mileage in domestic scheduled service was sufficiently large to plot a reasonably smooth curve.

Also pointedly showing the effects of improvements while in service is Fig. 4. The importance of this plot may be shown by the fact that accidents from this cause are twice as apt to be fatal as those from all causes.

In this figure there are three periods of note. First is the tremendous improvement in the period from 1938 to 1944. The abrupt drop to the almost perfect record of 1940 through 1944 can be attributed to two factors—the mandatory introduction of feathering propellers and the extremely reliable Wright and Pratt & Whitney engines in common use during that period. Of these, we believe the ability to stop rotation of a failed or failing engine was undoubtedly the dominant factor.

The second interesting period is the marked jump in the curve for 1945 through 1948. This was the time when the modern four-engined transports, with extremely high-power engines, were first put into service. The record speaks for itself in showing that the in-flight fire situation was not what it should have been when these planes were in their early development stages.

The final period is the abrupt drop off from the peak year, 1948, showing that the previously hazardous conditions have been brought under reasonable control through the close cooperation of the manufacturers, air lines, and CAA.

There have been, however, some instances of slow or ineffective corrective efforts that have upset the pilots and often tend to becloud the really excellent general efforts. Perhaps the most spectacular one is the high incidence of uncontrollable engine fires in a widely used modern transport. In 1945, in the military prototype, the first such incident occurred, resulting in a fortunate successful forced landing. In 1946, a similar incident occurred in commercial operation. The cause of

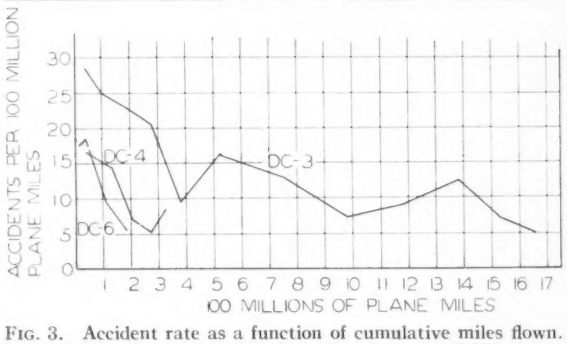


Fig. 3. Accident rate as a function of cumulative miles flown. Domestic scheduled service only. Source: CAB.

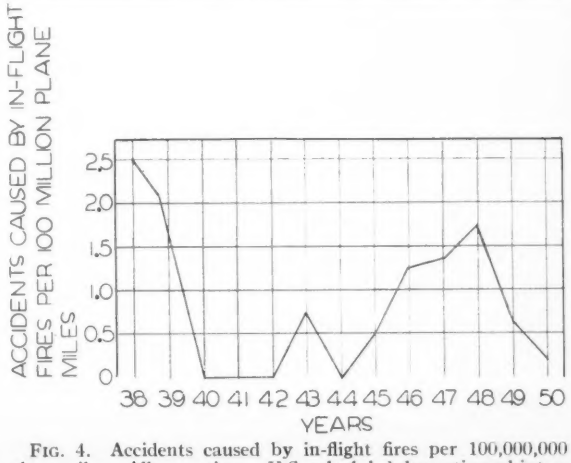


Fig. 4. Accidents caused by in-flight fires per 100,000,000 plane miles. All operations—U.S. scheduled domestic and international carriers. Source: CAB.

these initial fires was determined and corrected, but apparently the extinguishing problem was not solved, for we find in 1947 and again in 1950 fatal accidents caused by engine fires that the flight crews were unable to control. Again, last year, there was another such incident, but happily, as in the initial ones, a successful forced landing was made. In this unfortunate and lengthy history, there have been several different causes for the initial fires which have been subsequently corrected in each case, but the underlying basic accident cause, uncontrollability, was dealt with inadequately with tragic results.

Another problem that undermined the confidence of pilots who knew the details dealt with propellers. In this instance, after several vivid, but fortunately nonfatal, demonstrations of what happens when a blade snaps, a program was set up to replace the defective type with improved ones over a considerable period of months, a deadline of hours being placed on the service life of the former. Following another incident of in-flight blade failure, this program was accelerated, and all of the defective type were out of service in approximately two weeks, as contrasted with the prolonged initial replacement program. The slower program, it developed, had been predicated on the deadline of hours, mentioned previously, which had been based mainly on financial considerations rather than on, we think, a conservative technical evaluation of potential seriousness of the already demonstrated hazard.

In cases such as these, we feel strongly that intuitive judgment of the situation is often sounder than one based on statistics, particularly when they are financial ones. It is granted that such a judgment is often hard to defend, but the terrific cost to an air line, as well as to the industry in general, of a fatal accident should bear more weight than it often apparently does in high executive circles.

Leaving the design and development aspect of operations, we can logically progress to the actual flying of the equipment by the pilots. Occasionally the statement is heard that the pilots have not progressed with the industry. In this connection it is pertinent to note the increased complexity of air-line cockpits. Over the years, the instruments, controls, and gadgets have increased from 289 for the DC-3 to approximately 400 for DC-4, 522 for the CV-240, some 600 to 700 for the DC-6, to about 1,000 for the B-377. Ten years ago how many people had ever heard of V_1, V_2, ADI, TBS, TAI, RMI, VAR, VOR, ILS, Mach limitation, etc.? It is granted that the gadgets all have their purpose and have contributed to the increased level of safety, but who can say that they have really made the pilot's job easier? In fact, they have greatly increased the chances for confusion and mistakes, and the fact that the percentage of accidents attributed to "pilot error" has not increased with the increased complexity, but has remained relatively constant, is, we feel, proof of the adaptability and professional progress of the pilot group.

Simultaneously with this increased instrumentation and gadgetry has come the lowering of minimums and the raising of approach and stalling speeds. Ten years ago the common weather minimum was 500 ft. and 1 mile and the common approach speed was 90 m.p.h. Today at some fields we find minimums lowered to 200 ft. and one-half mile, while the approach speed has risen to 150 m.p.h. True, the alignment problem is more accurately solved by ILS, but, nevertheless, the time available for the pilot to orient himself properly after becoming "visual" has decreased tremendously from 40 to 12 sec. In commenting on records that show that under actual 200-$^1/_2$ conditions one of every three approaches is missed, Roe[5] said:

"This record is no reflection on the professional ability of the air-line pilot for he is doing the best possible job with the tools at hand. It does, however, demonstrate graphically the inadequacy of his tools."

We feel that this demonstrates also that minimums of 200-$^1/_2$ are, at this time, not realistic when the human equation is taken into account with the instrumentation and speeds presently provided. In order to correct this, even at the expense of increased cockpit complexity, the addition of an instrument such as the Zero Reader or perhaps automatic approach may be the answer. In this case, even though another gadget is added, the actual task would be simplified and the safety level raised.

Even as cockpits have become more complicated, so have the airway facilities. The number of ranges, ADF beacons, marker beacons, ILS, etc., have nearly saturated many areas. As more accurate fixes and approach systems have been evolved, the increased accuracy has been used to cut approach times and increase the number of aircraft movements, while holding the same level of safety. This, instead of easing the pilot's job, has, in most cases, complicated it further. In a recent fatal accident, there is a possibility that the multiplicity of facilities and choice of approach methods may have confused the pilot to the point that the ADF was tuned to the wrong station for the chosen approach method with the result a mass of tangled wreckage on a hillside.

The hitting mountain problem has been with us for many years, and the often noted tendency for the fatal lack of terrain clearance to be extremely small gives rise to speculation as to the number of cases where the safe margin was equally slight. In other words, no one really knows how great is the exposure rate to this type of occurrence. Recently an incident happened which shows how easy it is to have a false sense of orientation.

The flight was a long distance one over mountainous, European terrain. The wind forecast was badly in error, the actual wind being in the order of a 100-knot head wind instead of 20 knots, so the flight was uncertain of its ETA. Both ADF's were tuned and, although there was considerable snow static, identified on the destination station, and the ILS was likewise used. Presently both ADF's reversed, indicating an overhead, and almost simultaneously the ILS needle changed quad-

rants, confirming the position. The pilot requested and was granted let-down clearance from his 14,000-ft. approach altitude. However, for some reason, before descending he switched frequency and requested a VHF DF fix from the Air Force net in the area. This fix showed his true position to be 75 miles from the station, over mountainous terrain. If he had let down, on what was apparently sufficient proof of his position, there is little doubt that he would have become a statistic in the "pilot error" computations.

The point to be made here is that, unlike a mountain that always knows where it is, a pilot may at times mistake his position or else, as in the above case, receive erroneous indications of his position, and, acting on his best judgment, let down into a hill or mountainside. This has been amply demonstrated over the years, but little has been done to provide a positive answer to the problem, except for the abortive effort several years ago by the CAB to make a terrain warning device mandatory. Perhaps the order was premature, due to the unreliability of the popular device, but it appeared to the pilots that more effort went into proving that the device was unreliable than in improving it to a practical and useful point. One air line, however, TWA, did work on its terrain warning indicator and now has installed it on a voluntary basis. The author has talked to many TWA pilots concerning this and finds an almost unanimous approval of it.

Perhaps cockpit radar is a more sure and versatile answer, but a practical terrain warning device would eliminate 20 per cent of the fatal accidents causing 25 per cent of the fatalities and would reduce "pilot error" accidents by 6.5 per cent. We feel that this is an important area to which industry attention and action should be focused.

In planning design and operations, the average level of competence of the pilot group should be carefully kept in mind. Too often, it seems, operations are planned which require an exceptionally high level of skill and are not realistic in that, while average skill is adequate under normal conditions, trouble is invited under abnormal conditions of airplane malfunction coupled with unfavorable weather. That this is true is easily understood because the executives who do the planning are usually superior in intelligence and experience and have better access to information and, naturally, plan operations through their own eyes and capabilities. It is, however, a condition that should be guarded against.

Training

An integral part of operations and safety is training. It is obvious that constant training and checking in both old and new procedures is one of the cornerstones of flight safety. However, there is often a tendency to use intensive training to make up for design and operating deficiencies. In regard to this McFarland[6] says:

"The most promising solution lies in the simplification of the tasks of the air crew rather than in an attempt to improve the quality of the personnel, which is already of a high order in the civil air lines. The relationship between the difficulty of tasks and human performance has been simply expressed by the analogy of a number of people given the assignment of walking a 2-foot wide plank on the ground without falling off. The percentage of human error would be negligible. If the plank were reduced to a 2-inch width and raised a considerable distance off the ground, the number of failures would increase rapidly. Extending the analogy to the simplification of the cockpit, it would be easier to facilitate the task by increasing the width and lowering the height of the plank than to select a group with sufficient skill to be able to walk on the narrower plank higher above the ground."

Frankly, the pilot group feels we are walking a narrow plank.

An interesting training area that has been little explored to date is the use of electronic trainers to determine whether present procedures are straining the flight crew's ability to the breaking point. PAA has made some use of its Dehmel trainer in this light, changing procedures that have resulted in "crashes" of the trainer but to date no effort has been made to put a coordinated and well-planned research program along this line into effect. The results could prove very useful.

The use of intensified training at this time in an attempt to improve the air-line safety record should be, we think, only an interim measure until such time as planes and operations are simplified to the point where they are more compatible with human ability.

Regulation

The final facet in the air safety picture is regulation, having implications in all the previous fields—design, operations, and training. Although there is often the cry of "overregulation," clear thinking people will admit, the author believes, that it is, at its worst, a necessary evil. The best example of the effects of underregulation is the state of safety among the nonscheduled air lines. Some of these operators have excellent records, but there are many who cut the corners of sound practice, and the overall record shows the results glaringly.

There is a basic conflict in air transportation between economics and safety. It has often been said that the only 100 per cent safe aircraft is one that never leaves the ground. However, the economics of such would be nil, and the problem is where to adjust the meeting point of the conflicting interests. Here is where, oftentimes, it is necessary to have the CAA/CAB as a sort of umpire, balancing economics, safety, and public interest one against the other.

In discussing Fig. 2, the apparent influence of CAR 04 on the safety record of modern four-engined planes was pointed out. It appears that these regulations have put a minimum floor under the characteristics of these designs while at the same time allowing enough leeway for sound economics. However, this evenness of the

(*Continued on page 66*)

The Guided Missile—

Precocious Problem Child of the Military Art*

by
Clark B. Millikan†

Introduction

"THE CHRONOLOGICAL SEQUENCE that was followed in the preparation of this paper was a little unorthodox. First, as is usual, the general subject was suggested as one that might be of some interest. Then under pressure of a deadline, a definite title had to be determined, and only after this irrevocable step had been taken did I begin to reflect on just what should be covered. After some consideration I concluded that the title had, perhaps subconsciously, suggested itself to me because of the fact that its component words actually represented some of the most crucial and striking aspects of this recent and spectacular development, the guided missile. Accordingly, I have decided to take up the various terms in the title one by one and attempt to assign meaning and significance to each. In this way it may be possible to give a picture of the problem child by looking at him from several different points of view. I then propose to conclude with a brief account of how Uncle Sam is bringing up this unruly nephew to what is hoped will be effective and powerful maturity.

The Guided Missile

"To start with the title's beginning, what is it that is now meant by the term 'guided missile?' The first crude precursors of the guided missile appeared during

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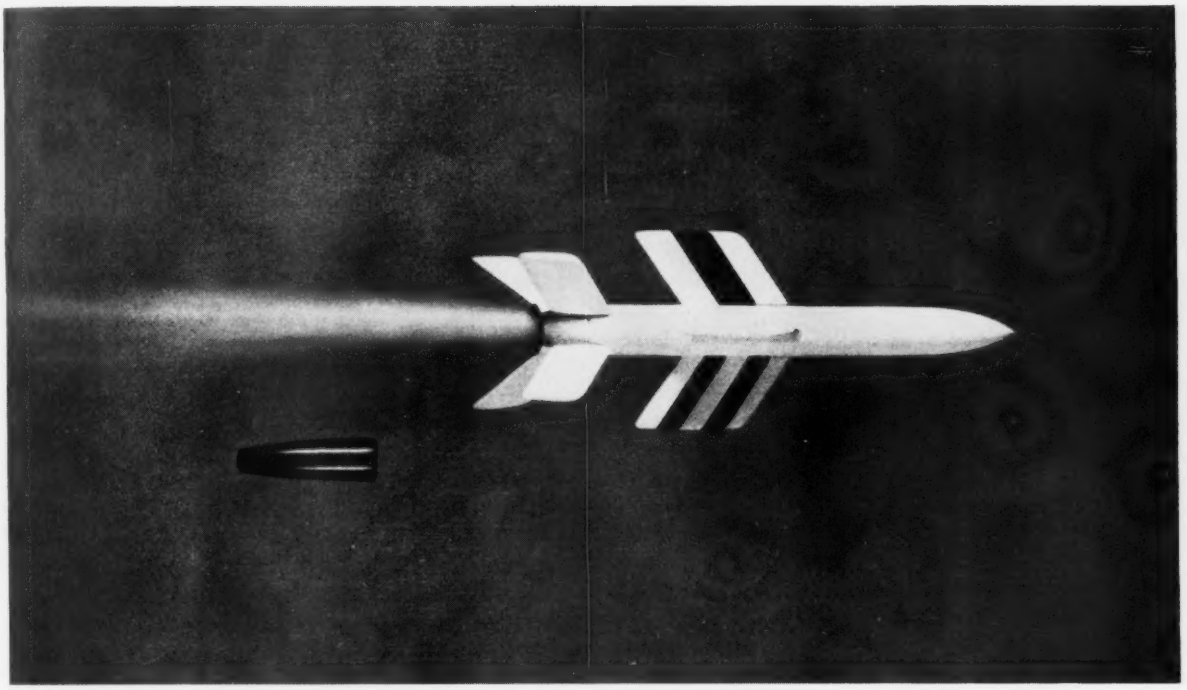
† Director, Guggenheim Aeronautical Laboratory, California Institute of Technology, and Chairman, Guided Missiles Panel, R.&D.B.

North American Aviation NATIV guided missile being launched from a tall tower at Holloman Air Force Base, Alamogorde N.M.



Ryan "Firebird" air-to-air guided missile is a rocket-propelled fragmentation shell that "homes in" on its target by means of a radar navigational system.

the last war primarily as a result of German developments. Guided glide bombs lacked only the propulsion element, but this omission so restricted their effectiveness that they played a relatively unimportant role. The V-1 buzz bomb and V-2 rocket were controlled by preset internal mechanisms but were not guided after leaving the launching area, in the sense that no subsequent information concerning the target or their deviation from the desired trajectory was furnished them. Thus, their accuracy was poor and their effect primarily psychological rather than strictly military.

"From these early and relatively ineffective ancestors has developed the large family of weapons that are now being actively worked on. These weapons may conveniently be grouped in categories corresponding to their principal military objectives. These categories, together with their associated conventional weapons, are: air defense by antiaircraft artillery and fighter planes carrying small caliber guns; antiship by naval guns, torpedoes, and bombing planes; tactical support by field artillery and strafing or bombing aircraft; and strategic bombing by long-range bombers. There are only two reasons for developing guided missiles to supplement or replace these 'classical' weapons: inability of the older weapons to do their job under modern conditions and higher effectiveness or efficiency of guided missiles compared with their more conventional competitors. The first may be illustrated by the case of antiaircraft artillery. Against modern aircraft flying at nearly the speed of sound and at altitudes of 40,000 ft. and above, the conventional antiaircraft gun is essentially useless and no foreseeable improvements in it can appreciably help matters. The guided missile seems the only possible replacement, but it, to be effective, must have tremendous speed (say twice that of sound) and extraordinary guidance accuracy. In the other three categories, conventional weapons are still effective but have limitations of range, dependence on weather, vulnerability, etc., which high-performance guided missiles could eliminate or greatly reduce. Thus, both reasons furnish powerful incentives for developing high-performance guided missiles.

"The qualification 'high performance' is what makes the problem so terribly difficult. To illustrate the difficulties, I shall consider only the two most important aspects of 'high performance,' although there are many others that introduce problems almost as serious.

"The first is speed. I have already indicated that antiaircraft missiles must have speeds of the order of twice the velocity of sound, say 1,200 to 1,500 m.p.h. It is now generally conceded that, for reasonable effectiveness and invulnerability, guided missiles of all types should eventually operate at velocities of this general magnitude or greater. This requirement of tremendous speed means that the missile size must be as small as possible, and even then the power of the motor must be enormous. Two types of power plant seem to be suitable—the ram-jet and rocket. Both involve powers per cubic inch of engine which are enormously larger than that of any other known power plant. Their development accordingly requires the solution of a host of formidably difficult engineering problems.

"The second aspect of 'high performance' is that of accurate guidance and control. To illustrate this prob-

lem, I shall consider only one of the types of guided missile as an example. The antiaircraft missile must intercept a very high-speed aircraft that may be at extreme altitude and which can engage in active evasive maneuvers. On the other hand, the range need not be more than a few tens of miles, and, during the missile flight, both target and missile will usually be on a 'line of sight' from a ground control station located at or near the missile launching site. To meet these conditions three major types of guidance system have been developed. These are beam riding, command, and homing or seeking. In all three the function of sensing, which in the past has been done by the human eye, and that of interpreting observations, done by the brain, have been taken over by electronic apparatus. Further the human operation of estimating the future behavior of target and missile is, in some systems, carried out by electronic computers. In addition, the manipulation of controls to produce the required missile maneuvers, which in aircraft is done by human muscles, is here accomplished by elaborate servo-systems that usually turn out to be as sensitive and unstable as the most jittery of prima donna athletes.

"I have mentioned only three of the simplest of the many types of guidance and control systems, but I hope this is adequate to indicate the extraordinary complication and difficulty of the problems involved. For long-range missiles against fixed targets the maneuverability requirements are much less severe, but the impossibility of using line of sight methods and the extraordinary accuracies required make the overall guidance problem even more difficult than is the case for the short-range antiaircraft missiles.

The Military Art

"The beginning of the title has afforded an opportunity of describing what it is that is being discussed. The end of the title—'The Military Art'—suggests a limitation on the fields of endeavor to which the guided missile can be applied. This limitation is a very real one at present and is likely to remain so for a long time to come. It is almost impossible to conceive of a peacetime or commercial application for any guided missile at present contemplated.

"However, even though guided missiles appear doomed to a monogamous wedding with the Military for a pretty respectable number of years, there will undoubtedly develop peacetime applications for many of the elements of the various guided missiles projects. Ram-jet and rocket motors and enormously complicated guidance and control systems are examples of elements that are now being developed only through the military support of the guided missiles program but which will certainly be incorporated in future commercial projects. Such eventual nonmilitary applications for their work furnish a solace to many engineers and scientists working in the field, but most of them will have to admit, in many cases sadly, that for the near future their sponsors and deities will be the gods of war.

Precocious

"Now for the adjective 'precocious' in the title, which is certainly appropriate in connection with the guided missile. Dr. Hafstad, a distinguished physicist who has been intimately connected with most of the striking recent applications of science to warfare, said the following in a speech a few years ago. 'I have no hesitation in saying that the guided missiles field is the most complex and difficult of the lot. . . .In neither my civilian nor my military experience have I seen a problem which includes so many branches of physical science.' When one realizes that 10 years ago the guided missile in its presently used sense had not even been conceived, while today several different missiles and complete systems are being successfully operated. It becomes clear that 'precocious' is certainly not too strong.

"The guided missile program has been subjected to much criticism by commentators impatient over the fact that there are as yet no operational guided missiles in the hands of service troops—in other words, that 'push-button warfare' is not 'just around the corner.'

"Although there have inevitably been mistakes and confusion in the program, it seems to me that such criticisms are based only on wishful thinking as to what would be nice to have, rather than on any understanding of what is technically possible. I hope that I have already given some idea of the unparalleled magnitude of the technical task of developing a guided missile. When one realizes that serious work on any scale was initiated only a little over 6 years ago, it seems to me that the present state of development instead of being blameworthy is truly precocious.

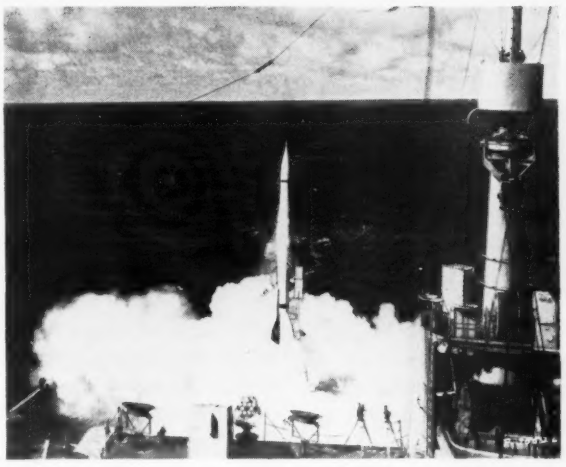
Problem Child

"And now to squeeze the last juice out of my title, let me consider the remaining phrase 'problem child.' The underlying reason for its applicability, apart from the technical problems already mentioned, lies, I think, in the following circumstance: When, toward the end of the last war, it became apparent that guided missiles might now be technologically feasible, there was no existing niche in the military structure into which their development could naturally and uniquely be fitted. To ordnance officers, the guided missile appeared as a device to extend the range and accuracy of guns, whether antiaircraft or bombardment. To airmen, it appealed as a natural development of the piloted aircraft, and, in fact, guided missiles were, for some years, always referred to as pilotless aircraft by the air branches of the Army and Navy. There was no single agency in the military service which could naturally take the new fledging under its cognizance and alone sponsor its growth. Accordingly, four more or less independent programs were started: one by the Air Force, one by the Army Ordnance Department, and two by the Navy, one under the Bureau of Ordnance and the other under the Bureau of Aeronautics. The latter two have been effectively coordinated since the appointment a few

years ago of a Deputy Chief of Naval Operations for Guided Missiles, but it is apparent that with such a number of different approaches the possibilities for confusion were great.

"The difficulties were intensified by the fact that the program was inevitably a terribly expensive one, requiring the construction of elaborate laboratory facilities and test ranges and that it was undertaken during a period of retrenchment and 'economy' in military budgets. Funds were appropriated by Congress to the three services individually, and this resulted in a competition, sometimes rather bitter, between Army, Navy, and Air Force, for Congressional favor. In such battles the 'public relations' expert almost always becomes an important character and in this case, unfortunately, all three of the services used the publicity weapon extensively and often unwisely. Glowing and inflated accounts of 'successful tests' frequently appeared, and the impression was given that guided missile developments were much further along than was actually the case. This conflicting and inflated publicity seemed to indicate a confusion, duplication, and lack of coordination in the overall program far worse than was the case in actuality. And the over-optimistic press releases resulted inevitably in a sense of disillusionment on the part of the press and Congress when the claims of 'tactical weapons available tomorrow or next week' failed to materialize. It was primarily these unwise publicity activities that were responsible for the criticisms of the program which have already been mentioned.

"On looking back now on this period, which extended from the end of World War II until fairly recently, it is clear that there was some duplication, overlapping, and certainly competition between the various cognizant agencies. Many more projects were started than could effectively be carried to fruition, and, in the subsequent pruning, many were dropped. However, I cannot help feeling that this shot-gun and somewhat haphazard approach was, in this case, not undesirable but was even essential. When work was started on the development of guided missiles there was no background of technical experience on which a judgment could be based as to which of the many possible lines of approach to any single objective would ultimately prove most effective. The only way in which answers could be found and the best path chosen was the expensive and inefficient one of trial and error. And, if the answer was to be found in the short time that international tensions made mandatory, then the various approaches had to be investigated simultaneously rather than in chronological sequence. Furthermore, the interchange of technical information at the working level was remarkably good, so that each of the competing groups had up-to-date information as to the technical approaches, successes, and failures of all the others. It is almost an axiom in science and engineering that the best way to avoid undesirable and fruitless duplication is by the free interchange of ideas between workers engaged on similar problems. Such interchange existed in the guided missiles field to an unprecedented degree.



Martin Viking high-altitude research rocket takes off from the deck of the Navy's guided missile research ship, the U.S.S. "Norton Sound."

"One more fortunate consequence should be mentioned of the setting up of many guided missile projects by four somewhat competing agencies. When work started 6 or 7 years ago, there were practically no scientists or engineers with any experience or knowledge of the tremendous complexities of the guided missile. In particular, there were no teams who had even considered the problem of integrating the enormous number of diverse components into a guided missile system. A large number of study projects made it possible to train a large number of such individuals and teams that could be used in other projects if their own were eliminated in the contractions dictated by the economy program. The most serious bottleneck in the entire field today is the lack of enough trained and experienced technical personnel. If it had not been for the earlier period of so-called duplicating projects, our present expanded program would be utterly impossible for lack of trained man power.

"There have certainly been headaches and difficulties in the raising of our infant, resulting from the multiplicity of sponsoring agencies, and in this sense he can justly be called a problem child. However, I am certain that the precociousness of the youngster now is directly associated with these headaches. If he had been brought up more deliberately, systematically, and efficiently he would today be many years less advanced than he actually is.

Bringing Up and Prospects

"At the beginning I said that, after exhausting the possibilities of the title, I would conclude with an account of how the problem child was being brought up. The primary responsibility is properly being carried by the three military departments who must use the boy when he grows up. Their sponsorship of individual projects, carried out by industrial, univer-

sity, and government agencies, has already been mentioned. Accordingly, I shall here consider primarily the part played by the Research and Development Board since this is my own chief point of contact with the program.

"The Committee members are a civilian chairman, which post I occupy at the moment, two other civilian members, two flag or general officers from each service as full members, and a number of deputy members from the services. All of these members serve on a part-time basis.

"In originally setting up the Committee structure Dr. Vannevar Bush made the difficult, but I feel extremely wise, fundamental decision that the members should be chosen for technical competence in the field. As a result my two civilian members are, respectively, the director of a large university laboratory and the engineering vice-president of one of our largest corporations. Both, in their daily life, are up to their ears in guided missile development projects for one or more of the services. The way in which such men can bring their intimate knowledge of guided missiles to bear on the Committee's problems without exhibiting the slightest prejudice or self-interest is remarkable proof of the wisdom of Dr. Bush's original decision. There is not the slightest question in my mind that, in such a position, really high-caliber men engrossed actively in the field can make an infinitely greater contribution than 'disinterested' outsiders. Corresponding to these civilians, the senior service members are the flag or general officers responsible for the guided missile programs of the three departments.

The Convair 774 supersonic self-launched rocket during firing at White Sands Proving Ground, N.M.

"The Committee is supported by about a dozen panels, each responsible for one of the technical subdivisions of the guided missile field: Guidance and Control, Propulsion and Fuels, Aerodynamics and Structures, etc. To furnish a broader survey over the entire technical scene, there is also a so-called Technical Evaluation Group. The members of all these groups serve on a part-time basis and are chosen in accordance with the same basic principle as are the committee members. The Panels contain the best civilian and military experts in their special fields, the civilians being almost always drawn from active guided missile projects. The five members of the Technical Evaluation Group are all civilians and are almost always senior engineers or scientists occupying positions of great responsibility on some one of the guided missile projects.

"Each of these groups meets several times a year, visits projects, laboratories, and test ranges, and submits detailed technical reports to the Committee. These reports are frequently critical of some aspect of the program and always contain numbers of specific recommendations for changes, eliminations, or additions. One of the most important results of these activities is the close contact and personal relationship that is thus developed between the working scientists and engineers from the various projects, laboratories, and proving grounds. Such personal contacts at the working level lead to far more integration and coordination of the overall program than would any number of directives imposed from above.

"The Committee meets every six weeks or two months, usually for a two-day period. It discusses the Panel and Technical Evaluation Group reports, adopts as Committee policy those recommendations with which it is in agreement, considers proposals for new projects, approves or recommends modification of programs for the following year, approves new experimental or test facilities, etc. As a matter of strongly supported policy our committee, unlike many of the others, keeps no transcript or stenographic report of its proceedings, the Executive Director making a record of all formal actions. The result is that the discussions are much freer than would be the case if a complete transcript were recorded. In some cases, indeed, the discussions become heated, but the number of cases in which a unanimous decision is not finally arrived at has been amazingly small.

"There have, of course, been critics of the whole 'Committee' method of the RDB, and it is certainly true that top control by a Committee is seldom effective in the management of an operating agency where the necessity for quick decisions and action makes it almost necessary that responsibility and authority be vested in an individual. However, the RDB is not an operating agency and does not attempt the actual administration of any of the research and development projects with which it is concerned. Its functions are primarily to bring technical and scientific knowledge and judgment

(*Continued on page 65*)

The Research and Development Board*

by

Edwin A. Speakman†

"THROUGHOUT HISTORY, man has turned periodically to warfare with his neighbor; from the first battle with clubs down to the last war, there has been a constant race for new weapons. Many of these, although generally considered to be of recent origin, were actually used in rudimentary form by the Greeks and Romans. For example, we think of biological warfare as a revolutionary and untried weapon, but early in history we find the ancients catapulting the bodies of their dead over the walls of besieged cities to spread the disease that they knew would follow, although they did not know why. The Greek historian Polybius, writing in the third century B.C., describes a crude type of chemical warfare used by the Greeks in the defense of Syracuse against the Romans. This involved the use of burning feathers in an earthenware vessel with a lid in which holes had been punched and spears inserted. In the words of Polybius, 'the Romans. . . . found themselves in a very distressing and embarrassing position, as they could neither stop nor endure the smoke.' Smoke screens were also used by the Gauls against Caesar, and 13 centuries later Genghis Khan, famous ruler of the Mongols, used chemicals in the form of huge balls of pitch and sulphur thrown at the enemy to produce a combination of smoke, choking fumes, and fire.

"Armored vehicles are usually presumed to have been an invention of the British during the First World War, but actually the Assyrian armies, and later the Greeks and Romans, employed a crude version of the tank. These 'tanks' were sheds or towers mounted on wheels, and, since some of them were 50 or more feet high, and therefore taller than the walls of the cities, a form of air attack resulted from their use.

PROGRAM SIZE

"It is therefore not unusual that the race for scientific weapons continues—it has had a long history—but it is somewhat startling to realize that, in this supposedly enlightened age, it is necessary that the Department of Defense and the Atomic Energy Commission engage the services of two-thirds of the nation's scientists and engineers and that the military research and development program represents an expenditure of nearly one and one-half billion dollars.

"The size of the Defense research effort is not only startling, but sobering and thought-provoking. We are confronted by the fact that the greatest portion of the creative thinking and effort of the nation's scientists and engineers is, of necessity, being concentrated on weapons, devices, and techniques of warfare. Not only is the nation as a whole spending a vastly larger sum on research and development than ever in its history, but most of this is going for military purposes. Obviously, this phenomenon is having a profound effect on our culture. There have been diversions and disruptions in the normal fields of teaching and of academic and industrial research. As Dr. Vannevar Bush stated in a recent report of the Carnegie Institution of Washington, there may be grave dangers inherent in the increased governmental regimentation of scientific research, although there appears to be no alternative method of administration.

"An incident that illustrates this point occurred about two centuries ago in the time of King George III and is recorded in the proceedings of the Royal Society of Great Britain. After our own Benjamin Franklin discovered the identity of lightning and invented the lightning rod, he published a paper on his experimental researches. This paper was widely read by British scientists. It appears that a certain Sir Henry Wilson repeated Franklin's experiment and came to the conclusion that a rod with a blunted end was more satisfactory than the pointed rod recommended by Franklin. The matter became controversial and reached the ears of the King, who sent for the President of the Royal Society, Sir Thomas Maitland, and this dialogue ensued:

" 'Sir Thomas, what are your views in the matter of the lightning rod?'

" 'Your Majesty, I find that the pointed rod is the better.'

" 'You are aware that our loyal subject, Sir Henry Wilson, found the blunted rod superior?'

" 'I am, Your Majesty, but I can only be guided by the results of scientific experience.'

" 'In that case, Sir Thomas, I think you should resign as President of the Royal Society'; and he did resign.

* Luncheon address given at Twentieth Annual Meeting, I.A.S., New York, January 29, 1952.

† Vice-Chairman, Research and Development Board.

"It should be observed, however, that, unlike scientists in totalitarian states, he left the King's presence with both his self-respect and his freedom.

RDB and Questions We Face

"Now I will tell you about the Research and Development Board, how it operates, and some of its accomplishments. We face such problems as how science can be organized on a billion-dollar scale by the Government so that it will be truly productive. Another question: How can our Government assure that originality and imagination with intelligence and vigorous initiative are freely and enthusiastically applied to its scientific problems by its most competent scientists?

Purpose of the Board

"The basic purpose of the Board is to bring about a research and development program in the military departments which will most actively promote our national security. More specifically the Board is directed: (1) to prepare a complete and integrated plan of military research and development, (2) to coordinate departmental research and development programs, and (3) to consider the interaction of research and development and strategy and to advise the Joint Chiefs of Staff in connection therewith.

"The Board is a policy-making agency, advisory to the Secretary of Defense, with the planning of research and development for military purposes the principal job. Therefore, RDB does not make contracts or direct internal administration of research. These functions belong to the military departments.

Composition of the Board

"The Board is composed of a civilian Chairman and two representatives from each of the military departments. Walter G. Whitman, formerly head of the Chemical Engineering Department, Massachusetts Institute of Technology, is Chairman. The Army representatives are Under Secretary Archibald S. Alexander and Major Gen. Ward H. Maris, Deputy Assistant Chief of Staff. The Navy representatives are Assistant Secretary Floberg and Rear Adm. M. E. Curts, Assistant Chief of Naval Operations. The Air Force representatives are Under Secretary Roswell L. Gilpatric and Major Gen. Donald L. 'Putt, Acting Deputy Chief of Staff.

Committees and Panels

"There are a total of 15 committees under the Board, each committee having cognizance over a technical field or type weapon. To give you an idea of the scope and variety of work, I shall mention the fields covered by our present committees and technical groups. These are: aeronautics, atomic energy, biological warfare, chemical warfare, electronics, equipment, materials, geophysics and geography, fuels and lubricants, guided missiles, human resources, medical sciences, navigation, ordnance, and technical information. Each committee is composed of representatives from the military departments and outstanding civilian experts, and one of the latter is the Chairman. For example, the Chairman of the Committee on Electronics is Donald A. Quarles, Vice-President of the Bell Telephone Laboratories. The Chairman of the Committee on Guided Missiles is Dr. Clark B. Millikan, Director, Guggenheim Aeronautical Laboratory, California Institute of Technology. Under the Committees, Panels are formed, also with a mixed military and civilian representation. Thus, throughout the Board structure, there is joint representation that combines civilians and representatives of the three Departments. In all, the Board has the services of some 1,500 part-time civilian consultants, committee members, and panel members, most of whom serve without compensation. They are all recognized leaders and authorities in their fields of science or engineering.

Board Staff

"In addition to the part-time technical Committees and Panels, the Board has a permanent staff organization of some 300 people, most of whom are professional scientists. The Staff collects and summarizes information, prepares plans and estimates, and serves the Board and various Committees. They have the primary job of gathering information on all research and development undertaken by the military departments and their contractors and of putting it in a concise form for examination by the technical experts of our Committees. The Staff includes about 60 military officers who are responsible for liaison with their respective departments in the various scientific categories of research. In this way, the military departments are closely tied in with the activities of the Board to assure that the programs are properly planned and effectively administered.

Relation to Joint Chiefs of Staff

"The Research and Development Board maintains a close working relationship with other agencies of the Department of Defense, such as the Joint Chiefs of Staff, the Munitions Board, the Central Intelligence Agency, Atomic Energy Commission, the National Science Foundation, and the National Academy of Sciences. In order for the Board and its Committees to evaluate scientific programs, it is necessary to have some idea of the operational and strategic needs of the military departments. This information is supplied by the Joint Chiefs of Staff in the form of strategic plans and military requirements that are used by the technical Committees of the Board to examine scientific programs. In this way, each important area of research and development is studied in its relation to military needs in order to assure that new weapons and

new techniques meet the requirements of the Armed Forces. The Board, on the other hand, advises the Joint Chiefs of Staff periodically with reference to new weapons and countermeasures. This information is in the form of reports or technical estimates of what new weapons and techniques will result from research and an estimate as to the date when these new weapons will become available. In addition, the Board also provides technical guidance to the Army, Navy, and Air Force to assist them in the administration of programs and the preparation of budgets and fiscal information.

Study Projects

"Another aspect of this program is the evaluation of new weapons systems by the Weapons Systems Evaluation Group, a small organization sponsored jointly by the Joint Chiefs of Staff and the Research and Development Board. This group makes studies aimed at finding out how well we can carry out an operation with some of our new weapons and what our military departments could do operationally if they had certain types of equipment which are now in the planning stage or which are not included in our development programs. These studies are also aimed at finding out what would be the effects or results of such operations if we were able to accomplish them. This work has an important bearing on research and development as a basis for determining the relative importance of future weapons. In addition the departments also sponsor basic studies on tactics, military operations, and the feasibility of undertaking certain actions by the use of scientific weapons. These studies are one additional means of assuring that the new scientific weapons that are developed have a definite application in military operations.

Informal Coordination

"I have spoken of the various technical Committees and Panels of the Board and how they operate to assure well coordinated programs. Although these are activities that receive formal recognition as important ways of coordination of research and development, there is at least one additional way in which coordination is brought about informally but more effectively at the working level in our Panels and Subpanels. When the representatives from the Services and our civilian experts, who are actually handling research and development in service laboratories and in industrial laboratories, meet together in our Panels and technical groups, they exchange ideas and compare notes directly across the table, and a great deal of duplication of effort is eliminated right there before any projects or work are even started. These actions are brought about informally so that the issue never requires formal policy action by the Board itself. I believe that the work of Committees and Panels is of tremendous importance, serving as a forum with no necessity for a vote—just getting together and talking over technical problems and questioning the other fellows' plans and opinions.

"On the other hand I do not want to give you the impression that the Research and Development Board settles all issues without considerable debate and disagreement. Competition among the military departments for support of certain programs is very strong and frequently leads to lively discussion. It is generally recognized, however, that only through the clash of divergent opinions can mistakes and shortcomings be exposed and the desirable distinguished from the undesirable. This is another way in which improvement and progress are made.

New Developments—Electronics

"I know that you want to hear something about new development in our weapons. I will mention several items without going beyond the limits of security.

"You have heard about *radar* and how well it was used in World War II. In fact, it has many commercial applications today in navigation of both ships and aircraft. Our program at the present time is aimed at increasing the range on small targets, such as aircraft and guided missiles, and of developing high-powered transmitters that will enable us to pick out and track enemy missiles or bombers. We have used *electronics* in so many commercial applications for communication, for television, and for automatic devices in the home that it is only natural that we find electronics playing a most important part in all aspects of military weapons. One of our new planes, for example, has a total of 40 per cent of its cost tied up in electronic equipment for that plane. In the case of one of our large bombers, for example, there are a total of some *1,200 vacuum tubes* used in electronic equipment so that we look upon certain type aircraft as flying electronic laboratories, with all their intricate systems for control of the plane, for navigation, for communication, for firing of their guns, and for locating targets by radar and for guiding missiles. As a result of this wide application of electronics, we have encountered many new problems that must be solved in order to assure *reliable* weapons. One problem concerns the development of more reliable electron tubes. This program is a most urgent one, and we have the support of the tube industry in this effort.

Guided Missiles

"Much has been said about *guided missiles*, and we have a very substantial development in this area which promises to provide weapons that can be launched from the ground against enemy aircraft missiles, others which can be launched from our own aircraft against various ground targets. Most of these depend upon electronic systems of guidance and are extremely complicated. An important aspect of this program is flexibility of design so that various types of warheads, including *atomic*, may be carried by guided missiles.

"In spite of the fact that our effort in the development of missiles is substantial, our experience is limited, and we still consider guided missiles to be relatively new and untried weapons. Some of you may remember the experiences that the Germans had with their V-1 and V-2 missiles. In 1944 and 1945, the Germans launched a total of 10,000 V-1 missiles and about 3,000 V-2 missiles. Of this number, only one-third reached the target area. Many were shot down by our own and British planes, as well as by antiaircraft fire. About one-third of this number, however, did not reach the target areas because of failures in the equipment at the launching sites and while the missiles were in flight. In the case of the V-2, for example, one-fifth of all the launching crews were killed by accidents at the launching sites. I mention these figures in order to stress the fact that in our present program we have made provision for extensive service testing of guided missiles in order to assure that they will be reliable and reach their targets accurately.

Escape Capsule

"As aircraft fly higher and at greater speeds, the problems of escape for the pilot become rather acute. Hazards of low temperature and sudden lowering of pressure, as well as the devastating effects of pressures of wind against the human body, are ever present. At the present time, however, there is a means of escape that has proved a success in practice. This consists of an ejection method that forcibly thrusts the pilot and seat high over the tail of the aircraft. There is now in development stage a type of *escape capsule* that is also forcibly ejected in the same way. The capsule protects the pilot from air blast, decreased oxygen supply, low atmospheric pressure and temperature, and high-acceleration forces if he has to abandon his plane while flying at very high speed and altitude. It is an integral, self-contained capsule that is ejected from the plane when the pilot pulls a lever. A parachute opens automatically and the capsule floats down with the pilot inside. He still has his oxygen equipment, the cabin is still pressurized, and he has been protected from the effects of the terrific air blast and deceleration. He can either bail out of the capsule or stay in it, for it can land on either land or water.

Gadgets

"At the present time, we are confronted with a host of well-meaning proposals from various sources; proposals for new weapons and gadgets. We certainly plan to confront any aggressors with bigger and better technical surprises in case he should break through our defenses. That will be forthcoming in due time, but our experience in Korea points to needs in a different direction. If we load ourselves down with so many complicated technical contraptions that we become immobile, like the Knights of the Middle Ages with their heavy armor, we will then fall prey to an enemy who fights in Indian style. We must, therefore, guard against the development of super weapons that are so complicated that our fighting ability is compromised.

RDB

"We believe that the Research and Development Board has contributed a great deal to the integrating of these programs that I have described and to an overall program of military research and development. If the task of coordination is not yet all that we should like it to be, at least we can feel that we have helped to bring about a fruitful cross-exchange of information. Not only are the services aware of what each other is doing, but, through our civilian Committee and Panel members, they are aware of relevant work that is being done by industry and universities.

Peacetime Applications

"I should like to remind you that not all of the money spent for military research and development goes up in the smoke of battle. Military research, however lethal its intent, nearly always produces something with a constructive application. Peacetime applications of biological and chemical warfare, two of the most potentially destructive weapons, have made important contributions to medical science. Studies of Rinderpest, one of the greatest enemy diseases in the world today, have produced scientific advances in the production of vaccine against thousands of diseases. The air-borne Magnetometer was a gadget developed to aid in the location of submerged submarines. In that respect, it proved to be successful as a tool for geophysical prospecting for valuable minerals and is now widely employed by commercial companies.

No Easy Answer

"With a program of research and development as large as I have described, we must be careful not to assume that future wars will be fought at great distances where human beings seldom come in contact with each other. We must be careful not to convince ourselves that science will provide an easy answer to all our problems. New and fantastic weapons may be of some assistance, but we must guard against trusting our future entirely to such devices. Great strides have been made and will continue, but there is no new weapon that we now know anything about that will eliminate the need for powerful, well-trained armed forces in the Army, Navy, and Air Force. We will need just as much hard work and unselfish devotion on the part of each individual as we have ever had in the past if our nation and liberties are to survive."

The Air Transport Business—

from the British Point of View*

by

Peter G. Masefield†

"It seems to me that to come from a foreign country—or at any rate a distant country—to talk about Air Transport to people who operate about two-thirds of the world's Air Transport mileage is rather like carrying coals to Newcastle, England—although perhaps that's not such a good simile today because coal would be very welcome in Newcastle.

"In fact, as you know, we in the United Kingdom today are facing another of those difficult periods brought about by the fact that we have bled ourselves white during the war. Indeed, some rather more than usually muddled politician said the other day, 'If we don't restore our backbone by showing a stiff upper lip, our last legs will probably stare us in the face with a resounding bang.'

"However that may be, we in Britain are determined not only to restore the stability of our economy—and in that I believe that Air Transport can play no small part—but also to stand alongside the United States and the other free nations in contributing all we can toward the struggle against Communist aggression.

"Of course, my subject just after that broad sweep of world affairs is about the situation of Air Transport as we in Britain see it today.

"It seems to me that we have reached today an extremely important phase in the development of this Air Transport business. Not only are we coming up to radically new means of propulsion, but also we are on the eve of a tremendous development in Tourist Class travel and steadily reducing fares. Our major problem is going to be, I think, to make sure that we have available adequate numbers of aircraft of the right type to shoulder the job. The real development of air transport is just beginning. Very significant, for instance, is the fact that although the average rate of increase of world Air Transport since the war has been running at a steady 17 per cent, in the past year, 1951, the rate went up to an increase of 25 per cent.

"What I would like to touch on briefly are two main points—first, how we in British Air Transport see the future developing, 'equipment-wise,' and second, how we feel the possible developments can improve that vital factor of our business—air safety.

Future Developments

"First of all, on the equipment side, the basic fact is, I'm sure, what all of us need to consolidate this business during the next 10 years are aircraft—tools of our trade—which will offer us substantially lower costs per seat mile; greater attraction to passengers, and by that I do not mean necessarily extra luxury; and still further improved safety characteristics.

"We in Britain believe that these three fundamentals can be met by three separate developments.

"First of these is the jet transport, although, for economy of operation, it will have to be produced in much larger sizes than anything so far revealed.

"Second, we foresee the requirement for the big turboprop airplane that we believe will come forward in

* Excerpts from a luncheon address, Twentieth Annual Meeting, I.A.S., January 31, 1952.

† Chief Executive, British European Airways.

two different configurations—the first of them an extremely large turboprop airplane for long range work and the second, a smaller turboprop airplane with equal seating capacity for short-haul work. That leaves the medium range field to the jet.

"Third, we look for the development of the large helicopter for intercity flying, up to distances of about 300 miles.

"In other words—and I think we would all agree on this—we must look for bigger aircraft that will give us substantially improved economy. And we must look for aircraft with noise and vibration much reduced, both to cut down our maintenance costs and to offer improved passenger attraction. I believe also that we shall see a move toward lower wing loadings, with the basic objective of gaining improved performance at height, but also bringing with them better take-off and landing qualities and with that, higher safety.

"We in the United Kingdom have, of course, a great and sincere admiration and respect for your highly developed American transport airplanes, such as the Stratocruiser, the DC-6B, the Lockheed 1049, the Convair 340, and the Martin 404. All of them appear to us to be fine 'work horses,' capable of earning substantial profits, as, of course, you are proving in service. We look on them with respect mingled, I must add, with just a little envy as a people short of dollars.

"Well, for one reason and another, we in the United Kingdom have more or less missed out on that generation of what one might call, the 'conventional modern transport airplane.' In consequence, we have been more or less *pushed* into the next phase—that is, the phase of the *turbine* aircraft.

"So, right or wrong (I believe right, but the next 18 months will show), we really have gone overboard on the turboprop and turbojet aircraft.

"For instance, we in B.E.A. have on order 26 Vickers Viscount 40- to 48-passenger aircraft. They are powered with four Rolls Royce Dart turboprop engines of 1,450 hp. each. We shall be introducing them into service from October of this year. And we are looking ahead to larger, developed versions.

"So far, we in B.E.A. have built up a limited amount of experience with propeller turbine aircraft. As of last week we have flown about 1,100 hours on four aircraft. During the next 12 months we plan to put in about another 2,000 hours on scheduled service with turboprop aircraft plus a good deal of test flying as well.

"Our colleagues and good friends in B.O.A.C. have on order 20 de Havilland Comet 36-passenger jet aircraft. The first line of them is powered with four de Havilland Ghost engines and the eleven aircraft in the second series have four Rolls Avons each. B.O.A.C. will begin introducing the Ghost-Comet into service from April of this year, and the first Avon Comet is flying this week.

"B.O.A.C. has on order also 26 Bristol 175 90-passenger aircraft. They are each powered with four Bristol Proteus turboprop engines of 3,780 hp. each. They will start coming into service in 1955, all being well.

"So these orders for 72 aircraft amount to a total of some hundred and ten million dollars. They represent the stake of the British Air Transport Industry in turbine aircraft. We have no new major type of aircraft on order which is not powered with jets or turboprop.

"Now I don't suggest that there is anything clever or remarkable about this. In fact, it's a bit of a gamble. Circumstances have simply dictated that we must skip a stage. If we had nationally-produced equivalents of the DC-6B and 1049 coming into service, I am sure that we should be happy about them and with them.

"In fact, one of the keenest disappointments I have experienced was that the project to go forward with a version of the Constellation, powered with Bristol Centaurus engines, had to come to nothing because of dollar shortages. The Centaurus Constellation would have been a fine aircraft.

"Anyway, a thing we in Britain do feel strongly—as I am sure you do also—is that for success in this highly competitive international field, an air line *must* have really competitive equipment.

"All being well then, we feel that our turbine transports should enable us to offer strong passenger appeal from three basic aspects: (1) a very low noise level in the cabins, (2) the virtual elimination of vibration, and (3) high block speeds.

"On the other hand, these turbine transports bring with them obviously a number of new problems and headaches. In particular, to get the best out of them we need to develop more complex operating procedures. In B.E.A., we are now developing what we call the 'Variable Booking Payload' technique, which we believe will make possible a notable advance by regulating the fuel loads according to precise calculations based on forecast winds, temperatures, and other variables.

"In essence, the 'Variable Booking Payload' approach relates the fuel loads to the significant variables after assessing them as accurately as possible and supersedes the old methods of 'Fixed Sector Fuel Loads' which have been the order of the day for short haul operations up to the present time.

"The 'Variable Booking Payload' technique requires the employment of advanced cruise control procedures and makes necessary the development of methods of exploiting commercially the varying increases of pay load 24 hours ahead of schedule, which results from varying the fuel load. The method has already shown us important advantages for piston engine type making possible an increase of 10 per cent in pay load on certain routes. The technique will be vital to gain the best economy from the turbine aircraft, and it should make possible an increase in pay load of about 20 per cent with these aircraft.

"So we believe, properly operated, the turbine aircraft can be made more profitable in service than can the equivalent piston airplane. The principle reason for this is that one can hope to gain a greater number of revenue ton miles in an hour at approximately equal operating expenditure compared with a piston airplane.

"For instance, we in B.E.A. have two new aircraft types of almost equal seating capacity and almost equal gross weight now coming into service. They are our 'Elizabethan Class'—the Airspeed Ambassador—and our 'Discovery Class'—the Vickers Viscount.

"A comparison of their pay loads over equal stage distances may be of interest. For a 500-mile operating stage, the Elizabethan, with piston engines, uses about 2,300 lbs. weight of gasoline, equivalent to 400 American gallons. For the same distance, the Discovery, with turboprop engines, requires some 4,000 lbs. of kerosene, equivalent to 600 American gallons. So the turboprop type needs 50 per cent more fuel than the piston type, measured in volume and 70 per cent more fuel, measured in weight.

"But the cost of the 600 gals. of kerosene in the United Kingdom is actually one dollar less than the cost of the 400 gals. of gasoline. So, in the United Kingdom, at any rate, the cost of the additional fuel is of no significance.

"For the same stage distance, for the same standards of fuel reserves, and for the same diversion distance, we have to lift nearly twice the weight of fuel in the turboprop Discovery as in the piston-engined Elizabethan. But, because of the lower installed weight of the turboprop power plants in the Discovery, that type carries almost exactly the same weight of pay load as the Elizabethan for a 500-mile sector distance. Both aircraft operate at the same gross weight of 52,500 lbs., but the turboprop Discovery achieves a 15 per cent faster block speed than the piston-engined Elizabethan.

"For shorter distances than 500 miles, the advantage lies with the piston-engined type. For longer distances than 500 miles, the turboprop increases its relative advantage. That means that, for these two airplanes, 500 miles is the crossover point between the piston and the turboprop—of course, leaving out of account the relative passenger attraction qualities of the two aircraft.

"Incidentally, use of the 'Variable Booking Payload' technique for the turboprop airplane on the 500-mile stage, which I have quoted, cuts down the amount of fuel needed for the operation and for the reserves by some 1,500 lbs. or 20 per cent while maintaining exactly the same standards. It's fair to say, of course, that the V.B.P. method reduces the fuel required by the Elizabethan by a substantial amount also—something like 10 per cent.

"Obviously, the problems are pretty complex, but I think one can say that the reasons we are sold on the turbine power plant are really these: (1) We can gain a higher cruising speed; (2) We can increase the pay load for all but the shorter stages; (3) The cost of power-plant maintenance and overhaul seems likely to be lower than those for comparable piston types; (4) The internal noise and vibration are much reduced; and (5) We believe turbine aircraft will be more attractive to passengers.

"It all adds up to the fact that we can hope to gain a higher speed at a lower cost with increased passenger appeal. If we succeed, that will mean a powerful competitive advantage.

"I must add also, of course, that we are conscious that we still have an enormous amount to learn. However, by operating two DC-3's powered with Dart turboprop engines on freight services, we are gaining an invaluable background of experience that will help us greatly in getting the best out of our new 'Discovery' class aircraft later on this year.

"On the plain-jet side I will say very little, except that I am sure that B.O.A.C.'s operations with the Comet are going to introduce a new era into Air Transport.

"At the same time, I'd like to make this point. We don't know of a jet airplane that could not—*in theory*, at any rate—be made more economic to operate, at about the same speeds, by the use of propellers. The problem with the high-speed propeller is, of course, noise. If that can be alleviated, then I am sure the propeller has a lot of life left yet.

"This statement is not going to be a hit with jet transports that I am sure are going to sweep the board in the next 10 years for medium stage operations—between 1,500 and 2,000 miles. But it does state the facts, as they stand today, on that terribly important matter of operating flexibility.

"Of course, what we all really need is an aero-engine that combines the virtues of the plain-jet *and* the propeller-turbine.

"Maybe the answer will be found eventually in the Ducted Fan compromise, which seems promising. Or maybe it can be found in an engine with a two-speed gear to the propeller driven from a turbine. Maybe, on the other hand, it can be found in a simple by-pass arrangement whereby the propeller can be used for take-off and for climb and 'holding', but where it can be feathered while all the energy is put into the jet for normal high-altitude cruising.

"I don't know what the answer is likely to be. But what I do know is that, as yet, we've hardly started down this turbine-transport path. And I'm sure that it is going to bring to all of us in the Air Transport business throughout the world the most tremendous advances in passenger attraction and in lower costs.

Helicopters

"There is one other type of equipment which I would just like to touch on, which we believe can develop a long way in the next decade. It is the large transport helicopter.

"We in B.E.A. have recently put out to the British Aircraft Industry an outline Specification of Requirements for a multiengined helicopter with accommodation for up to 45 passengers and with a cruising requirement of 150 m.p.h. I don't know what it will look like or when we might get it—perhaps 1958 might be a reasonable guess. But we believe that if we *can* get what we are after, it will open up opportunities for revolution-

izing the transport between city centers up to about 300 miles from each other.

"In this connection, I believe that the really fundamental need to push the helicopter along at a reasonable speed is a power unit properly designed for the job from the start.

"At the present moment, nearly all helicopters are using what one might call 'botched-up' conversions of standard aero-engines. I hope nobody will feel hurt by that phrase. But I do believe we need some new thinking here. And the large rotating surfaces of the helicopter seem a 'natural' for some sort of jet unit.

"It's not 'good engineering' to twiddle a stalk from the bottom when one can push it round efficiently from the tips.

"And on another point, we feel that to unload the rotor and to achieve reasonable cruising speeds the future helicopter should have a stub-wing, which is also useful, of course, for stowing the undercarriage.

"Anyway, from a background of 4 years of helicopter services with S.51's, we believe the large helicopter has a big place to play in short distance air transport in the future. But to achieve success, the helicopter must be able to operate to standards of reliability, regularity, and punctuality as least equal to those of the fixed wing type. That means, among other things, the cruising speed of not less than 150 m.p.h. we have specified.

Safety

"Now finally, perhaps I may be allowed to touch briefly on one or two aspects of air safety. I don't know how much a fear of the air still handicaps the development of our business on both sides of the Atlantic, but, I suspect, a great deal. We must win out here. Although I believe it's eight times safer to ride on a scheduled air line than in a Paris taxi—or maybe a New York taxi for that matter—we can certainly aim much higher still.

"I am sure the astronomic figures for the numbers of 'passenger-miles-per-fatality' mean nothing to the average man in the street. What he is interested in and impressed by is '*How Often?*' If one wants to be cynical, from an operating point of view I would say that no air line can afford to have a fatal accident more often than once in about every four years—no matter how many passenger miles it may fly in the interval. So the big air line has got to be safer than the small air line to achieve the same results.

"This business of air safety is a big subject—which Jerry Lederer has made very much his own. My belief is that we can improve air safety from an Air Transport point of view—and at the same time achieve still higher regularity—if we can persuade the 'Powers that Be' to concentrate still more on two things: first, precise navigational aids and second, developed approach aid.

"Even in these days we still have that occasional tragedy of an airplane running into a hill. That should *never* happen.

"As time goes on, whatever may be the outcome to the controversy between 'Decca' and 'VOR/DME,' in my opinion, we must see that we get set up on *every* domestic and *every* international route that we operate a really complete coverage so that all times and in all circumstances every Captain in command of a transport airplane knows precisely where he is, and the controllers on the ground know it too.

"Certainly with the jet aircraft and the new problems of high-speed 'Jet Streams,' it's going to be even more important.

"Although I don't want to enter into that controversy, we in B.E.A. do favor Decca because it offers a visual presentation already well developed in the form of a pointer moving over a map which is in advance of anything else we have experienced so far. In addition, Decca is accurate down to ground level, which will help our future helicopters.

"On the approach side, we want to see the further development of high intensity lighting right down to and including runway 'center-line' lights. In addition we want to see FIDO introduced at the key international airports.

"On another side, our experience with London 'Early Warning Approach-Radar' leads us to believe that the development of such equipment can be of great value indeed in improving air traffic control procedures and in sorting out the random arrivals into an orderly arrival rate.

"There is one other aspect of air safety which is being discussed a great deal at the present time—the backwards facing seats. I won't express an opinion there except to say that we have yet to receive proof that backwards facing seats can offer substantially better safety characteristics compared with properly designed forward facing seats.

Finally, although the air transport fleets of the world—excluding Soviet Russia—are now carrying something like 40 million passengers a year, which is more than four times as much as in 1938 before the war, I am certain that we have as yet hardly begun. Today, after 30 years of Air Transport, the scheduled route mileage of the world's air lines adds up to a total of about $1^1/_4$ million miles. That compares with the 800,000 miles of railroad track that exists after 130 years of that rather antiquated means of progression.

"But even so, we have a long way to go. I believe that the Air Transport business is going to become one of the greatest industries of the world. And because it links city with city and nation with nation in a way no other means of communication can do—except perhaps television—the influence of Air Transport on world affairs can only be good. And we must never forget that ours is an industry of service.

"With new and more developed aircraft coming into service, what we need so much, I believe, is a true Freedom of the Air, not just the limited so-called 'Freedoms' that are really restrictions.

"The technical advances that are just around the corner now are going to lead to ever *swifter* and ever

cheaper air transport. The question remains, of course—Can our civilization keep pace with the technical advances? Can we in due course cut through the developing coils of red tape—sticky on both sides—which seems to smother us?

"With the developments that lie ahead, I believe that we shall see the day when no major city in the world is more than *one hour* from any other major city.

"Already in 25 years, we have seen speeds multiply four times—from the 120 m.p.h. of the Ford Trimotor to the 480 m.p.h. of the Comet.

"In another 25 years we may see—with the winged-rocket—speeds go up by much more than another four times. But first of all, our aim must be to get the fares right down.

"There is, I believe, every prospect of air fares undercutting surface fares, whether by land or by sea, as we are able to progress scientifically and with our Tourist Class and Coach thinking.

"And as these things come about, there can be almost no limit to the increase of traffic, and we must look for much larger aircraft than we have contemplated yet.

"All that is in the realms of the future. There is a tremendous lot of work ahead. In Britain, our greatest problem of all is perhaps production—to turn out adequate numbers of the new aircraft quickly enough in the face of a vast effort on the vital rearmament program.

"But in the meantime, I must confess that one of the most refreshing things is to be here and to see again the energy with which *you* are tackling the problems. Even in the 3 years since I was last here, one can note many significant advances that can mean so much to the future. And in those directions, in cheap air travel as in others in this brave new world, the United States is leading in the path of progress.

"I hope that our own turbine aircraft are going to act as a useful spur in their progress also."

The Guided Missile—Precocious Problem Child of the Military Art

(*Continued from page 56*)

to bear on the three services' projects and to see that the overall program is as well-balanced and effective as it can be made. The technique that our Committee has used to attain these ends includes the requirement that any new project proposed by one service be presented and 'sold' to the committee, whose members can and do ask searching questions in the process. It also involves open discussion of the suggestions and criticisms of the Panels and Technical Evaluation Group. And finally it has as an essential element many hours of discussion, by the committee members among themselves, of the program, the individual projects, gaps, weaknesses, and duplications. The participating officer members, who are responsible for the three services' programs, are unusually competent and conscientious men. Under such circumstances, it is inevitable and difficulties will be corrected, programs sharpened and improved, and gaps filled without any necessity for formal directives or 'cracking down' tactics by the Committee in all but extremely rare instances. Thus, in spite of an almost total absence of fireworks and dramatic edicts in the formal actions of the Committee, I am convinced that it has effectively done its assigned job. I should mention, at this point, that I have served as chairman for only a little over 2 years so that this accomplishment must be attributed to the leadership and wisdom of my two distinguished predecessors, Dr. Karl Compton of M.I.T. and President Fred Hovde of Purdue, who developed the techniques and established the patterns which I have only had to follow

"Something over a year ago, as international tensions increased and defense problems became rapidly more urgent, it was decided at high policy levels that the guided missile program should be greatly accelerated, not only in its research and development aspect, but even more important, in its production and service use phases. Accordingly, K. T. Keller, Chairman of the Board of the Chrysler Corporation, was appointed to a newly created post, Director of Guided Missiles, reporting directly to the Secretary of Defense. Mr. Keller has had a tremendous influence. It is now certain that, as a result of his wise and energetic actions, the most militarily needed and technically advanced guided missiles will be in production and available for combat use years earlier than would otherwise have been the case. It will now be only a short time before our Precocious Problem Child is grown up and ready to play his part in the defense of our free world against the totalitarian tyranny that threatens it. That part will be a major, and may well be a crucial, one."

The Air-Line Pilots Look at Safety

(*Continued from page 51*)

safety record suggests a corollary: the planes were tailored to meet exactly the regulatory requirements, in at least several respects. This, though understandable in view of the intense competition among manufacturers, is not exactly desirable because it tends to stifle safety progress. However, competition being the American way of doing things, the situation will probably remain much the same in the future, which points to the constant necessity for the CAB to make the requirements ever higher as the state of the art permits.

Much the same situation exists on the air lines in regard to their operating rules, CAR 41 and 61. Here, however, there is discernible a tendency on the part of some lines to conduct their operations on a safety plane above that required by the Government agencies. This sometimes puts them at a competitive disadvantage in spite of their higher safety record, since it is as much the other fellow's record as one's own that determines the desire of the public for air transportation. Therefore, the CAB should always be alert to incorporate in the regulations, as applicable to all, those advances of any carrier which raise the level of flight safety.

As inferred above, the regulations should be fluid as well as realistic. Where weak spots show up, the regulations should be modified to cope with them. A recent case in point was the amendment of the stalling regulations of CAR 04. In this case, a regulation that had served well for several years not only became a barrier to new development, but, in the case of one airplane at least, its literal application gave rise to a more dangerous condition than the one it was designed to prevent. The regulation, with the support of manufacturers, air lines, and pilots, has now been modified, and the condition referred to above is in the process of being rectified.

In providing this fluidity, the annual Airworthiness Review of the CAB Safety Bureau is extremely important. Although some dissenting opinion on this subject has been heard from industry quarters, the pilots feel that this is the right way to go about the problem. Incidentally, at the most recent meeting in August, 1951, the pilots were pleased with the reception that was accorded their points of view, and we would like to take the opportunity to assure the industry that this was not a flash in the pan effort. Sayen[7] has said:

"The pilot's welfare is tied to the safety and dependability of the operation of his aircraft. A large part of the activity of ALPA must, therefore, be devoted to doing all possible for an increased standard of air safety. If there is a malfunction of any of the complex component parts which make up the modern aircraft, the airline pilot is the first one who will be cognizant of such defects and who may suffer from their inadequacy or malfunctioning. He must, then, be in a position to make his voice heard on such matters and he must be a powerful and independent spokesman in the field of air safety."

Conclusion

In this paper the author has tried to show the great importance of air-line safety to the sound and rapid development of this still growing industry and to point out some areas where improvement can be readily made.

Air-line safety is influenced by many factors, but it appears that the human limitation factor is the one offering the best chance for improvement of the presently stabilized record, not by more severe selection or training, but rather by designing operations and equipment to conform more adequately with human ability.

By implementing the three suggestions—mandatory reverse pitch, "shoe strings and rubber bands," and a terrain warning device—it appears likely that fatalities could be cut 25 per cent, accidents by 20 per cent, and "pilot error" accidents by 40 per cent. In these cases, human limitations would remain the same, but the tools would be designed to overcome them.

The pilot's success in flying the plane is, after all, the ultimate test of all safety efforts. As Sayen has said, the pilot is the first to know when things go wrong, and he can often sense in advance the chance of things going wrong. This paper has been an attempt to present a few ideas from the "men up front" as to how to raise the safety level.

To quote the Colonial Airlines slogan, "Safety Is No Accident." It is rather the result of the proper integration of a sound design with good operations. We feel that, in the past, in accomplishing this integration more attention has been given to economic factors than to human limitations. The pilots, by their intimate association with this integration of design and operations, in spite of our sometimes overly subjective approach, have much to offer toward the improvement of safety. We hope that use of this reservoir of information will be made to an increasing extent in the future.

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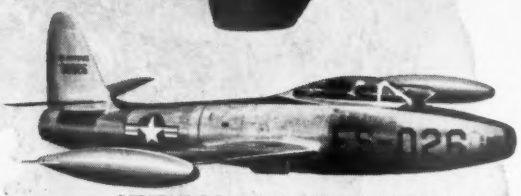

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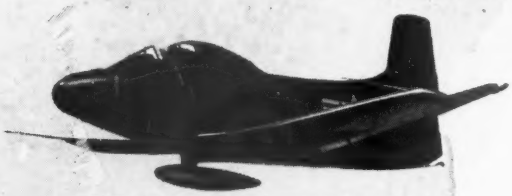

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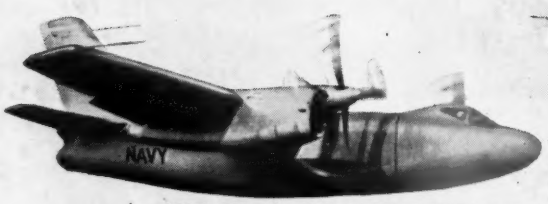

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I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

Shock-Tube Studies of Transonic Flow over Wedge Profiles

By

Wayland Griffith

Princeton University

Steady flow fields around two-dimensional wedges have been studied for Mach Numbers between 0.85 and 1.80 using the shock tube. It has been found that the location and shape of detached shock waves are independent of the wedge angle as long as the shock is not near to attachment.

The position of the sonic line and the pressure distribution over the wedge have been calculated from the density fields measured with a Mach-Zehnder interferometer. For a given wedge, identical pressure distributions are found over considerable range of supersonic flows. These results suggest simple formulas giving the drag coefficient for each wedge angle which are expected to hold in most of the transonic speed range.

Experimental data on the drag of a thin wedge through the entire transonic range are available for the first time and are in excellent agreement with recent theoretical calculations based on transonic small-disturbance theory.

Ripple-Type Buckling of Sandwich Columns

By

A. Cemal Eringen

Illinois Institute of Technology

The problem of local instability of thick sandwich columns having orthotropic cores is treated under two different types of loading: (a) axial compressive loads acting at the edges of face plates; (b) bending moments acting at the ends of the sandwich column. End points of the face plates are assumed to be pinned. The present method is, however, applicable to general end conditions and for arbitrary axial and transverse loading. It is shown that the deflected shape is neither symmetric nor antisymmetric, but asymmetric. Numerical calculations and curves are made for various types of cores employed in industry. The results are found to be in good agreement with the experimental data.

Aerodynamics of Blasts

By

L. Ting and H. F. Ludloff

New York University

The problem of a blast passing over the surface of an arbitrary flat structure is investigated. The pressure and density fields in the whole domain behind the advancing blast are obtained in explicit analytic form. As a simple example, the constant pressure lines (isobars) and the constant density lines (isopycnics) are plotted for a strong blast of pressure ratio 7.308, passing over a wedge surface. Comparison with the interferograms taken in Bleakney's laboratory shows surprising agreement. The "slipstream" connected with the Mach reflection of the shot comes out as a thin strip, in which the density gradient is steep but finite.

To obtain an analytic solution, no cone field transformations are used, as previously, because they restrict the generality of the results. Instead: (a) a Lorentz transformation of the coordinates is introduced, (b) the solution is given in terms of a Possio integral, (c) a "reflection" of the boundary condition is carried out and (d) a "lost boundary condition" is taken into consideration.

A High-Speed Schlieren Technique for Investigation of Aerodynamic Transients

By

Walter S. Bradfield and Walter Y. Fish

Institute of Technology, University of Minnesota

Development of a simple high-speed schlieren technique for investigation of aerodynamic transients is described and sample photographs are shown. A spark light source was developed which was capable of delivering bursts of up to 250 photographs at a frequency as high as 16,000 photographs per sec. A simple, inexpensive camera for recording the data photographically was devised and constructed in the laboratory. The photographic units were adapted to the schlieren equipment that was on hand and data were recorded at Mach Number 3.5 in an intermittent wind tunnel.

Please do not order Preprints of these papers at this time. See page 90 for Preprints that are immediately available.

Supersonic Wing-Body-Tail Interference

By

George Morikawa

Hughes Aircraft Company

The study of wing-body-tail interference is generally complicated by nonlinear effects, particularly in the description of the flow field behind lifting surfaces. In this paper, these difficulties are avoided by restricting the study to angle of attack near zero for in-line configurations in which both wing and tail lie nominally in the same horizontal plane. Comparison of interference effects on the tail due to the two *limiting* representations of the flow field behind lifting wings—namely, the vortex sheet and line vortex—shows the same qualitative behavior for the limiting cases of the design parameters. Thus, the indications are that this analysis, which essentially yields the *maximum* interference, may be applied to predict the behavior of configurations in which the tail is not in the same plane as the wing—i.e., where the maximum interference occurs at non-zero angle of attack.

The Effect of Nonlinear Aerodynamic Characteristics on the Dynamic Response to a Sudden Change in Angle of Attack

By

Telford W. Oswald

Douglas Aircraft Company, Inc.

The effect of nonlinear pitching moment and lift variations with angle of attack on the dynamic response to a sudden change in angle of attack is considered.

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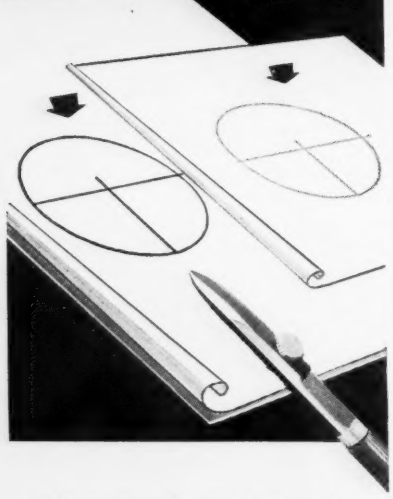

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An approximate solution to the nonlinear equation of motion is developed. Several numerical examples are considered, and the results of the approximate solutions are compared with the accurate results of numerical integration as well as the classical linearized solution. The effect of a nonlinear moment curve on the determination of stability derivatives from flight-test data is discussed in the light of these examples.

The Compressible Boundary Layer

By

George B. W. Young and Earl Janssen

The RAND Corporation and University of California at Los Angeles, Respectively

The laminar boundary-layer equations in integral form as obtained by Moore are solved on the mechanical differential analyzer. The method of analysis permits the use of the best known variation of the air properties with temperature. Solutions are obtained for Mach Numbers ranging from incompressible speeds to the hypersonic regime at ambient temperatures of 100°, 400°, and 800°R. for both insulated-plate and heat-transfer cases. From these results, an approximate design procedure for the calculation of the characteristics of both the laminar and turbulent boundary layers is obtained and presented as an aid to missile designers.

Two-Dimensional Losses in Turbine Blades

By

Charles A. MacGregor

Propulsion Research Corporation

Tests have been made on three typical turbine blades in a two-dimensional cascade tunnel. The tests were run at varying angles of attack, stagger angle, solidity, and downstream survey stations at a Mach Number of about 0.4 and a Reynolds Number of 6.5×10^5. The static pressure distribution about the blade was measured by 27 static pressure taps. The wake behind the blade row was surveyed and the loss determined.

Calculations were made of the boundary-layer loss at the various angles of attack, stagger angle, and solidity using the measured pressure distribution. The calculated loss was found to agree with the measured loss even though the pressure distribution varied greatly. It was found that the loss on the suction side of the blade was about six times as large as the loss on the pressure side. This was the result of the shape of the pressure distribution about the blade.

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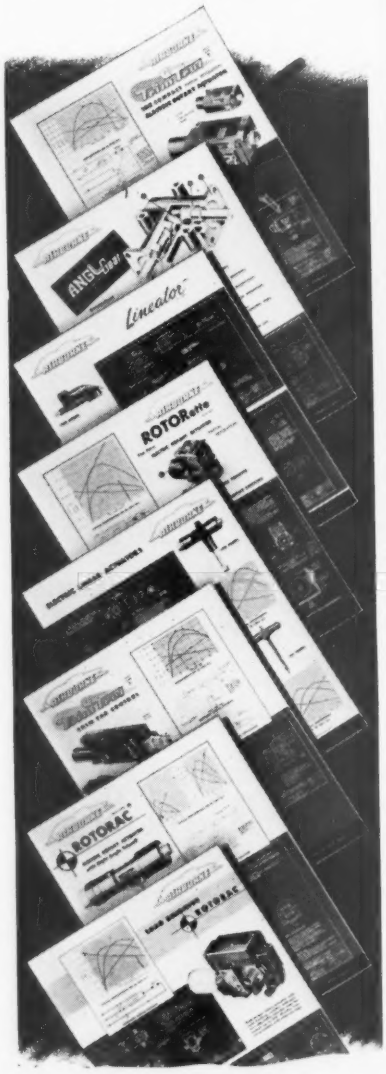

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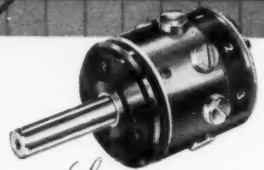
potentiometers



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Linear and functional output, rugged construction, ball bearings, small size, low torque, syncro-type mount.

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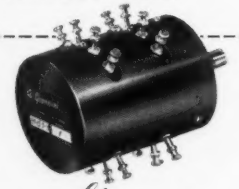
Push-pull motion, linear and functional output, high resolution, rectilinear potentiometer



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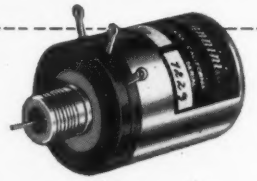
Functional and linear outputs, coils independently adjustable, variety of flexible assemblies.



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Discharge measurements made behind the blade row showed that the wake spread out as it moved downstream. The loss did not increase greatly in the first $^1/_2$-chord length behind the blade row, even though the shape parameter did.

Heat-Transfer to Constant-Property Laminar Boundary-Layer Flows with Power Function Free-Stream Velocity and Wall Temperature Variation

By

Solomon Levy

University of California at Berkeley

Numerical computations have been performed for the boundary-layer form of the energy equation for incompressible flows with power function variation of free-stream velocity ($U_1 = Cx^m$) and of wall temperature ($T_0 = Ax^\gamma$), the pertinent solutions of the momentum equation in this case being those of Hartree. The numerical computations given herein are to some extent a repetition of those given by Schuh and by Chapman and Rubesin, the object of the present computations being the resolution of discrepancies appearing in the previous solutions and an extension of their range. I.B.M. machine calculations were employed in the finite difference calculation presently utilized, the results thereof covering a range of wall temperature function exponents γ from -2.5 to 4.0 and of Prandtl Numbers from 0.70 to 20.0 for four values of m ($m = 4$, $m = 1$, $m = 0$, $m = -0.0904$). The accuracy of the numerical computations is examined in detail, and the accuracy of the computed functions at the wall, which determine the heat-transfer rate, is estimated to be within 2 per cent.

Examination of the results reveals that the results of Schuh for the flat plate are in error. For the range of the calculations, it was found that the local heat-transfer coefficient can, with the exception of large negative γ values, be expressed with ± 5 per cent as:

$$\frac{(hx/k)}{\sqrt{U_1 x/\nu}} = B(m, \gamma)\sigma^\lambda$$

where the exponent λ of the Prandtl Number σ varies from 0.254 to 0.367 for $-0.0904 < m < 4$ and where the function $B(m, \gamma)$ can be approximated by the equation:

$$B(m,\gamma) = \left(\frac{2\gamma}{m+1}+1\right)^{0.37+(0.12m/m+1)} \times \left[0.57\left(\frac{2m}{m+1}+0.205\right)^{0.104}\right]$$

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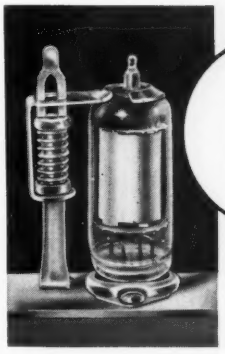

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I.A.S. News (Continued from page 21)

Problems, Arthur A. Brown, Installation Engineering Laboratory, Pratt & Whitney Aircraft Division, United Aircraft Corporation; and **Aircraft Fire Prevention,** Raymond D. Kelly, M.I.A.S., Superintendent of Technical Development, United Air Lines, Inc.

News of Members

▸ **Alfred Africano** (M.), Staff Engineer in charge of Aircraft Rocket Motor Design and Development, Propeller Division, Curtiss-Wright Corporation, has been appointed an Adjunct Assistant Professor, Aeronautical Engineering Department, College of Engineering, New York University. In this latter capacity, Mr. Africano is currently teaching a new graduate course, "Introduction to Rocket Propulsion." This course was initiated last February at the university.

▸ **Professor Leonard Bairstow** (F.), Chairman, Aeronautical Research Council, Great Britain, received a Knighthood during the recent conferring of honors last New Years by King George VI. Sir Leonard has been a Vice-President of the Royal Aeronautical Society.

▸ **George F. Chapline** (F.), Vice-President, Fairchild Engine and Airplane Corporation, and General Manager, Fairchild Engine Division, was named Chairman of the Industrial Council of the Long Island Association.

▸ **Charles H. Chatfield** (F.), Secretary, United Aircraft Corporation, was elected to the Board of Directors of the Manufacturers Aircraft Association, Inc., for 1952. This action took place at the M.A.A. annual meeting on January 29.

▸ **Martin Goland,** (A.F.), Associate Director for Engineering, Midwest Research Institute, has been appointed a member of the Committee on Aircraft Construction, a technical affiliate of the N.A.C.A. Mr. Goland is also serving as Chairman of the Subcommittee on Vibration and Flutter, N.A.C.A.

▸ **John K. Northrop** (F.), President, Northrop Aircraft, Inc., was elected a member of the Board of Directors for the National Aeronautic Association.

▸ **Norbert Edward Rowe** (A.F.), Technical Director, Blackburn and General Aircraft, Ltd., of England, has been appointed to the Board of Directors of that company.

▸ **Archibald Edward Russell** (F.), Director and Chief Designer (Aircraft), The Bristol Aeroplane Company, Ltd., England, was granted the honorary degree of Doctor of Science in Engineering. The presentation was made by the British Prime Minister, Winston Churchill, in ceremonies held at Bristol University, England, on December 14.

▸ **Hector R. Skifter** (M.), President, Airborne Instruments Laboratory, Inc., was appointed Vice-Chairman of Long Island Association's Industrial Council.

▸ **H. L. Stevens** (M.), Principal Director of Equipment, Research and Development (Air), Ministry of Supply, England, was named a Commander in the Civil Division of the Most Excellent Order of the British Empire. Mr. Stevens' name was published in the New Year Honours List.

▸ **George C. Sullivan** (M.), Patent Counsel, Lockheed Aircraft Corporation, was elected to the Board of Directors, Manufacturers Aircraft Association, Inc., for the current calendar year. The election took place at the M.A.A. annual meeting on January 29.

▸ **John F. Victory** (M.), Executive Secretary, N.A.C.A., was made a member of the Board of Directors, National Aeronautic Association.

SOLAR ENGINEER HONORED

William C. Heath (A.F.), Chief Design Engineer, Solar Aircraft Company, was awarded a Certificate of Appreciation for "the patriotic service rendered to the Technical Industrial Committee, Joint Chiefs of Staff, during World War II." The presentation, which took place at Solar on December 28, was made by Major Gen. William B. Kean, U.S.A., Commanding General of the III Corps, Fort MacArthur, Calif., at the request of the Secretary of the Army. Shown during the presentation ceremony are (left to right): General Kean; Rear Adm. G. R. Henderson, U.S.N., Commander, Naval Air Bases, 11th and 12th Naval Districts; Mr. Heath; and Brig. Gen. R. H. Ridgely, Jr., U.S.M.C., Acting Commanding General, Marine Recruit Depot, San Diego.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of I.A.S. members. All members are, therefore, urged to notify the News Editor of changes as soon as they occur.

Lieutenant George L. Bergst, Jr., U.S.M.C.R. (T.M.), D Company, 12th S.B.C., M.C.S., Quantico, Va. Formerly, Mathematician "A," Douglas Aircraft Company, Inc.

First Lieutenant Stanley Bernstein, U.S.A.F. (T.M.), Missile Project Officer, Ordnance Guided Missile Center, Redstone Arsenal, Huntsville, Ala. Formerly, Aerodynamicist, Guided Missiles Division, Fairchild Engine and Airplane Corporation.

Lieutenant (j.g.) Clayton C. Blout, U.S.N. (T.M.), BOQ, Treasure Island, San Francisco. Formerly, Chief, Technical Data Unit, Air Materiel Command, St. Louis.

Walter Bodofsky (T.M.), Draftsman "A," New York Office, Chase Aircraft Company, Inc. Formerly, Junior Engineer, Piasecki Helicopter Corporation.

Roger P. Brewer (T.M.), now Senior Engineer, Goodyear Aircraft Corporation.

Harold G. Brilmyer (M.), Assistant to the President, Huck Manufacturing Company. Formerly, Structural Designer, Structural Research and Development Group, The Glenn L. Martin Company.

Millford E. Collins (A.F.), Chief Engineer, Bureau of Aeronautics Representa-

When Nobody Knows the Answer

One of these days you may come face-to-face with a metal problem that does not seem to have an answer.

That is the time to think of these International Nickel Company metallurgists. They are constantly improving and modifying nickel alloys to meet new conditions. They are always ready to help you with specific problems involving metals for aircraft use.

Over the past 50 years, Inco has developed a family of metals for hundreds of different applications. In one branch of the family, for example, is a group of heat-resisting alloys—Inconel®, Inconel "X"®, the Nimonics and Incoloy®—all now important in the aircraft industry.

Elsewhere on the family tree, you will find other alloys—each with certain special characteristics. Often, there is a better-than-even chance that one of Inco's alloys offers exactly the properties you are looking for.

Of course, this does not mean that somebody at Inco can dip into the files and come up with a pat answer to every new problem. All the answers have not been found yet. But a tremendous amount of research has been done, and you can probably benefit in one way or another from it.

When nobody knows the answer, Inco's metallurgists keep going until they have investigated all possible metals and alloys that might do the job. In fact, the men in Inco's Technical Service (and in their Corrosion Engineering and High Temperature Engineering Services, as well) have one primary goal: to help you determine whether an Inco Nickel Alloy or some *other* metal will serve your purpose best.

No matter what your metal-selection problem may be, all the technical facilities of Inco are available to help you solve it. There is no charge, no obligation of any kind. For prompt technical help whenever you need information about metals, all you have to do is get in touch with: "Technical Service,"

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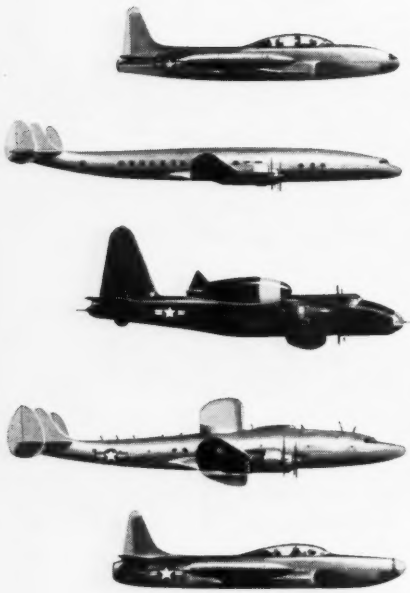
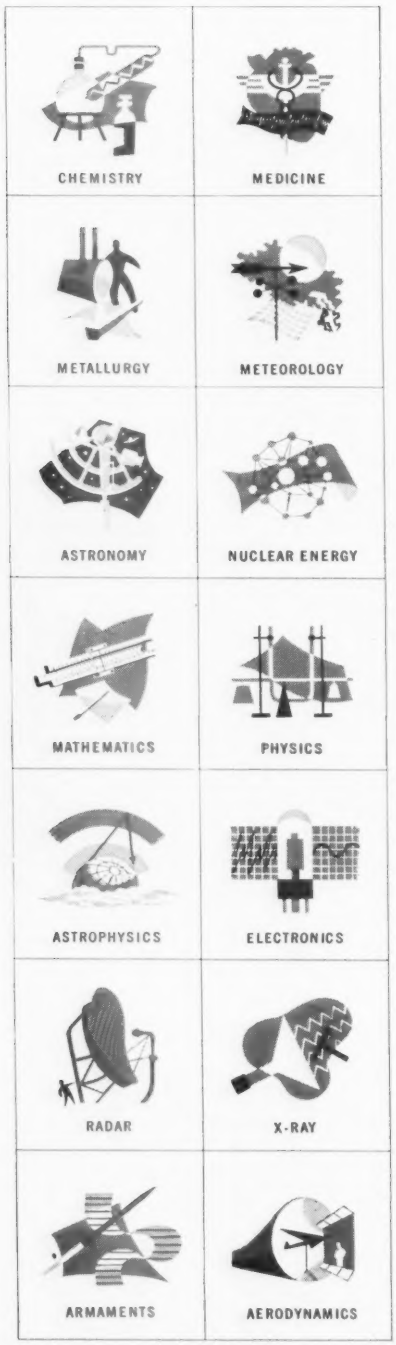
Leadership demands constant achievement



T-33 JET TRAINER
SUPER CONSTELLATION
P2V NEPTUNE
MILITARY CONSTELLATION
F-94 STARFIRE



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New buildings, providing laboratories in nearly every known science, have been added to Lockheed's Research Center in Burbank, Calif. Each building was designed for a special purpose. Each contributes to research, testing, invention or design —to help solve any new aircraft need or problem.

Lockheed's new 5-story Engineering Building, for example, houses a streamlined science headquarters, where engineers delve into such subjects as atomic research, pilotless aircraft, jet transports and advanced supersonic fighters.

SCIENCE CENTER

Lockheed advanced blueprints go to work in the new Research Center, which includes an aerodynamics laboratory, testing laboratory, wind tunnel, electronics laboratory, weather laboratory, chemistry laboratory and hydraulics laboratory. Here, meteorologists check the effects of every kind of weather on every vital plane part—shooting Sahara sand into engine bearings, growing tropical fungus on wiring, building Arctic ice on leading edges. These, and hundreds of other scientific tests, result in greater dependability in Lockheed planes.

Another advanced building at Lockheed is the massive Hall of Giants, which contains the nation's largest industrial equipment for building aircraft.

The new designs and methods which are developed almost daily at Lockheed are necessarily classified today. When they can be talked about, they will go down in history along with the many other Lockheed engineering firsts.

tive Office, Naval Industrial Reserve Aircraft Plant, Dallas, Tex. Formerly, Chief Engineer, O. & R. Department, Naval Air Station, Corpus Christi, Tex.

Captain Sidney E. Danyow (T.M.), Student Officer, U.S.A.F. Institute of Technology, Dayton, Ohio. Formerly, Aerodynamicist, Boeing Airplane Company.

Seymour J. Deitchman (M.), Aerodynamicist, Bell Aircraft Corporation. Formerly, Associate Research Aerodynamicist, Cornell Aeronautical Laboratory, Inc.

Charles E. Erlandson, Sr. (T.M.), now Junior Draftsman, Engineering Department, Economy Forms Corporation.

James C. Floyd (M.), Chief Engineer, A. V. Roe Canada Limited. Formerly, Works Manager, Avro Canada.

Milton Glossa (M.), Project Engineer on Navy KD2G Target Drone, Aircraft Division, Globe Corporation.

Squadron Leader W. Alex Goodall, R.C.A.F. (T.M.), now Assistant Resident Engineer, A. V. Roe Canada Limited.

Landon R. Gray (M.), Vice-President and General Manager, Sheridan-Gray, Inc., 131 N. Benita Ave., Redondo Beach, Calif. Formerly, Cofounder and Vice-President, Hufford Machine Works, Inc.

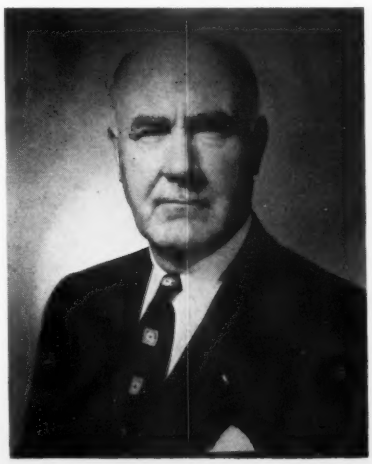
Mark Heaney (M.), Design Engineer, Stanley Aviation Corporation. Formerly, Project Engineer and Field Test Director, Muroc Division, Bell Aircraft Corporation.

Le Roy A. Herrmann (T.M.), now Junior Engineer, Illinois Testing Laboratory.

John R. Howard (T.M.), Project Engineer on Military Evaluation Tests of a Guided Missile, Coordination and Analy-

KIDDE DIRECTOR

Major Gen. Edward M. Powers, U.S.A.F. (Ret.) (A.F.), Vice-President and Director of Engineering, Curtiss-Wright Corporation, was elected to the Board of Directors of Walter Kidde & Company, Inc., last January. General Powers, who retired from the Air Force in April, 1949, joined Curtiss-Wright in June of that year. In February, 1951, he was named a Director of that company. Currently, he is a member of the Industry and Educational Advisory Board, Arnold Engineering Development Center.



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sis Branch, Ordnance Engineering and Development Division, White Sands Proving Ground, Las Cruces, N.M. Formerly, Aerodynamicist, North American Aviation, Inc.

Karlis Irbitis (M), Design Engineer "A," Canadair Limited. Formerly, Chief Designer, Canadian Armature Works.

Ensign Santo A. Irlandi, U.S.N.R. (T.M.), Student Officer, All Weather Flight School, U.S.N.S. (AWF), Naval Air Station, Corpus Christi, Tex. Formerly, VS-ATU 6, N.A.S., Corpus Christi.

C. R. Irvine (M.), Chief Engineer, Guided Missile Division, Consolidated Vultee Aircraft Corporation. Formerly, Assistant Chief Engineer, Convair.

Edward A. Kurzawa (T.M.), Research Assistant to Dr. A. M. Lippisch, Collins Aerodynamic Research Laboratory, Division of Collins Radio Company. Formerly, Material Liaison Manager, Fort Worth Division, Consolidated Vultee Aircraft Corporation.

C. P. Liljengren (M.), General Manager, Aerosmith, Inc. Formerly, President, Flight Equipment and Engineering Corporation.

Waldemar F. Mayer (M.), Consultant. Formerly, Consulting Engineer, AiResearch Manufacturing Company.

Walter F. McGinty (A.F.), Sales Engineer, Transco Products, Inc. Formerly, Vice-President, Director of Aircraft Sales, Delco Chemicals, Inc.

Lieutenant Edward S. Miller, U.S.A.F. (T.M.), now with Engineering Branch, Flight Test Division, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

John Myroniuk (T.M.), Engineering Draftsman, Republic Aviation Corpora-

NEW POSITION

Ralph J. Eschborn (M.) has joined Jack & Heintz, Inc., as Staff Engineer. Prior to this appointment, he was associated for 4 years with N.A.C.A.'s Lewis Flight Propulsion Laboratory in Cleveland as an Aeronautical Research Scientist. During World War II, Mr. Eschborn served as Chief of the Engine Unit, Electrical Branch, Equipment Laboratory, Wright Field, Ohio.

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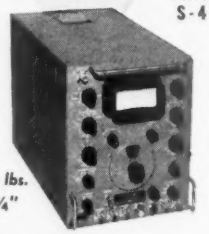
PULSESCOPE
BY WATERMAN

MODEL
S-4-A



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Video Amplifier band pass up to 11 mc ... optional Video delay 0.55 μs ... Pulse rise and fall time better than 0.07 μs ... Video sensitivity of 0.5 p to p/inch ... S Sweep 80 cycles to 400 KC either triggered or repetitive ... A Sweep 1.2 μs to 12,000 μs, R Delay 3 μs to 10,000 μs ... Directly calibrated on a precision dial ... R Pedestal (or sweep) 2.4 μs to 24 μs ... A & R Sweep Triggers available externally ... Internal crystal markers of 10 μs ± 50 μs ... Built in precision amplitude calibration ... Operates on 50 to 1000 cycles at 115V AC.

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Also RAYONIC Cathode Ray Tubes
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tion. Formerly, Engineer, East Coast Aeronautics, Inc.

Robert B. Phillips (A.M.), Supervisor, Maintenance Training, National Airlines. Formerly, Operations Instructor, National.

Miss M. Jeanne Place (T.M.), Engineer, Aviation Gas Turbine Department, General Electric Company. Formerly, Test Engineer, General Electric.

Joseph B. Prather (T.M.), Senior Design Draftsman, American Pipe and Steel Corporation. Formerly, Wind Tunnel Operator, Southern California Cooperative Wind Tunnel.

Howard R. Reiss (T.M.), Naval Architect, Hydrodynamics, David W. Taylor Model Basin, Md. Formerly, Research Assistant, Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn.

Harry L. Richardson (T.M.), Project Engineer, United Aircraft Products, Inc. Formerly, Senior Test Engineer, Ram Jet Division, Wright Aeronautical Division, Curtiss-Wright Corporation.

Grady M. Slagle, Jr. (T.M.), Research Specialist, Engineering Mechanics, Southwest Research Institute. Formerly, Design Engineer, Air Conditioning Design Group, El Segundo Plant, Douglas Aircraft Company, Inc.

R. Dixon Speas (M.), Consultant in Engineering and Operational Phases of Air Transport and Associated Fields, Domestic Terminal Building, La Guardia Field, New York. Formerly, U.S. Representative, A. V. Roe Canada Limited.

Joshua Tabatchnik (M.), now Engineering Group Leader, Weights and Structures, Chase Aircraft Company, Inc.

Edwin L. Thomas (T.M.), Structures Engineer, Texas Engineering and Manufacturing Company. Formerly, Structures Engineer, McDonnell Aircraft Corporation.

Allison J. Wilcox (T.M.), Design Draftsman, Yoh Engineering Company. Formerly, Engineering Draftsman, Northrop Aircraft, Inc.

Robert S. Winter (M.), Design Engineer, Rohr Aircraft Corporation. Formerly, Instructor, San Diego Junior College.

Kenneth K. Yap (T.M.), Designer—Draftsman, Frank Mayer Engineering Corporation. Formerly, Design Draftsman, Kaiser Engineers.

Corporate Member News

• **Allis-Chalmers Manufacturing Company** . . . Available upon request is Bulletin 51B7149B, *Allis-Chalmers Totally-Enclosed Fan-Cooled Motors With Tube-Type Air-to-Air Heat Exchangers.* The heat exchangers described are in ratings from 40 hp. at 600 r.p.m. through 800 hp. at 3,600 r.p.m.

• **Aluminum Company of America** . . . A giant extrusion press, said to be two and one-half times as powerful as any extrusion press now in operation in this country, has been installed at Alcoa's Lafayette (Ind.) Works. This press, which has been leased from the U.S. Air Force, exerts a force of 13,200 tons. With it, Alcoa will reportedly be able to extrude not only aluminum shapes of a given thickness substantially larger in cross section than possible heretofore but also shapes of a given size substantially thinner . . . New wear-resistant anodic oxide coatings for aluminum, which form an integral part of the metal they protect, are being released to licensees. For use where high resistance to abrasion is desired, these aluminum oxide coatings cannot be chipped or flaked from their parent metal.

• **Aluminum Company of America and The Glenn L. Martin Company** . . . Alcoa has acquired the U.S. patent rights to the Martin Hard Coating for aluminum. The Martin finish is similar to the Alumilite coatings in hardness and structure.

PIASECKI'S TRACTOR-TRAILER

The XH-16, shown in the accompanying artist's drawing, was recently moved from its assembly jig to its "berth" in the final assembly area at Piasecki Helicopter Corporation. The XH-16, which has a 77½-ft. fuselage, can carry 40 passengers or 32 litters. It is powered by two Pratt & Whitney R-2180-11 engines. A second one of these helicopters, now being fabricated, will use shaft turbine engines; it is believed to be the first of the transport helicopters to use this type of power plant.

• **American Helicopter Company, Inc.** . . . Clarence M. Belinn, M.I.A.S., President of Los Angeles Airways, Inc., and William C. Jordan, former President of Curtiss-Wright Corporation, have been elected to American Helicopter's Board of Directors.

• **American Steel & Wire Division, U.S. Steel** . . . A general sales meeting, attended by approximately 100 sales officials, was held in Cleveland on January 23 and 24. During the succeeding three weeks, separate sessions were held in the eastern, central, and western sales areas for all sales personnel. National Production Authority and Office of Price Stabilization rulings constituted the major topic of discussion at the meetings.

• **Aviation Engineering Corporation** . . . In response to the need for a continuing educational program devoted to new fuel gaging developments, Aviation Engineering has instituted such a course at its training school, Avien Fuel Gage Service School. It is planned to operate the course on a monthly basis as a service to the users of Avien equipment.

• **Beech Aircraft Corporation** . . . The U.S. Army Field Forces recently accepted four "hand-made" YL-23 aircraft, the military version of the Beechcraft Model 50 Twin-Bonanza. This aircraft is said to be the largest fixed-wing airplane operated by the U.S. Army and the first twin-engined ship to be operated by the Field Forces.

• **Bell Aircraft Corporation** . . . Leston P. Faneuf, who is Secretary-Treasurer of the corporation, has been named to the newly created position of Assistant General Manager of Bell.

• **Bendix Products Division, Bendix Aviation Corporation** . . . A recently purchased North American B-25 bomber has been fitted with laboratory equipment for landing-gear tests which permits test engineers to obtain simultaneous recordings of more than 16 different functions at an instant during a take-off or a landing. The airplane reportedly is being used to field-test wheels, brakes, shock struts, steering units, and other devices being designed for improved ground handling and landing characteristics of airplanes in general.

• **Boeing Airplane Company** . . . A B-47 Stratojet modification program has been

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arranged between Boeing and the U.S. Air Force Materiel Command. In this program, the Grand Central Aircraft Company facilities at Tucson, Ariz., will be used for special changes in the completed B-47.

• **Canadair, Ltd.**... The Royal Canadian Air Force is now using a more powerful and heavier version of the Canadair Four. This later aircraft, designated the Canadair C-5, is said to be powered by 2,400 hp. Pratt & Whitney Twin Wasp engines and to have a gross weight of 86,000 lbs.... J. Geoffrey Notman, Executive Vice-President and General Manager of Canadair, has been named a Senior Vice-President and a Director of Electric Boat Company, the parent concern of Canadair.

• **Canadair, Ltd., and North American Aviation, Inc.**... The Canadian version of North American's F-86E Sabre, now being built by Canadair for the Royal Canadian Air Force, will be known as the F-86E Star.

• **Consolidated Vultee Aircraft Corporation**...All guided missile activities, including all electronics and related propulsion activities, have been integrated to form the Guided Missile Division. There are now two guided missile units within the division, one at San Diego and the other at Pomona. Chief Engineer for the Guided Missile Division is C. R. Irvine, M.I.A.S.... The Convair Management Club of the Fort Worth Division, in cooperation with Texas Christian University, is currently presenting courses in Human Relations in Industry and Production Costs.

• **Curtiss-Wright Corporation**...The delivery of the first "Banshee" Simulator was made recently to the Glenview Naval Air Station, Ill. This 2F9 Simulator was developed by the Electronics Division... The U.S. Air Force has accepted two flight simulators for the B-50D bomber. Curtiss-Wright is also working on flight simulators for the B-36 bomber and C-119, C-124, and C-97 cargo planes.

• **Fairchild Camera & Instrument Corporation**...Frederick P. Willcox, Vice-President and Research Director of the corporation, has been awarded the 1952 Photogrammetric Award of the American Society of Photogrammetry. This honor, which is given annually for the outstanding invention in the field of aerial photography, was presented to Mr. Willcox for his invention, the new Fairchild Rapidyne aerial camera shutter. This device is said to permit more accurate photography at higher flying speeds than was previously possible.

• **Fairchild Engine and Airplane Corporation**...Admiral John H. Towers, U.S.N. (Ret.), A.F.I.A.S., has been elected a member of the Fairchild Board of Directors. Admiral Towers is a Vice-President of Pan American World Airways.

• **General Electric Company**...A program to produce armament equipment that the company has already developed for the Boeing B-47 Stratojet bomber has been announced... The 1952 edition of the *Instrument Transformer Buyer's Guide* has just been released by the Meter and Instrument Division. This 94-page publication, GEA-4626E, is available from G-E.

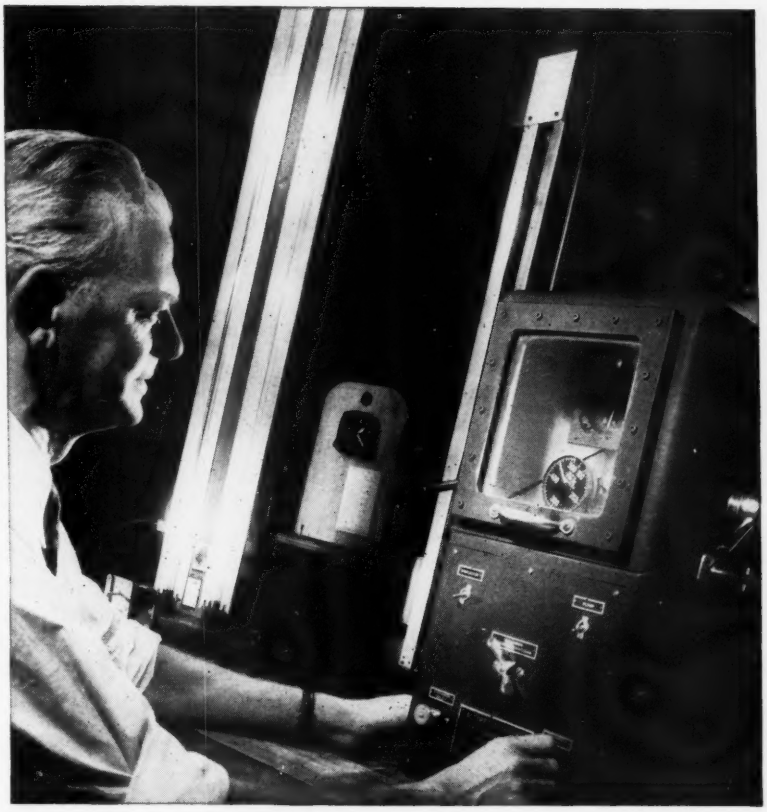
• **The Goodyear Tire and Rubber Company**... Three new divisions have been organized recently at Goodyear Aircraft Corporation. Two of them are the Metalcraft Manufacturing Division with C. E. Lehman as Plant Superintendent and the Fighter Division with Albert Goulding as Plant Superintendent. The third one is for the handling of the production of rocket components for the Government. W. H. Cline will take care of the overall administration and coordination of the Rocket Division. A one-storied, steel-framed building, now under construction to house production machinery, is expected to be ready for use in May.

• **The International Nickel Company, Inc.**... Bulk concentrate from 3,650,000 tons of nickel-copper ore is now being pumped annually through International Nickel's recently completed 7½-mile pipe line, running from the newly built Creighton (Ontario, Canada) concentrator to the reduction plants at Copper Cliff, Ontario. This pipe-line artery has been integrated into an elaborate pipe-line system that also carries tailing, or waste material, from both Creighton and Copper Cliff to a disposal area midway between the two plants. Approximately 1,800 tons of concentrate and 8,200 tons of tailing are produced from the milling of 10,000 tons of nickel-copper ore per day at Creighton. Water added to the concentrate makes a pulp that flows through the pipe line at the rate of 800 gals. per min. The tailing pulp flows at the rate of 2,500 gals. per min.

• **Jack & Heintz, Inc.**... Rocke International Corporation has been retained to act as the sales organization for Jack & Heintz in the world market. Rocke International will handle the sales of Jack & Heintz aircraft accessories, replacement parts, and electric motors in countries outside the continental U.S. and Canada. The Jack & Heintz line of magnetos will be distributed, as in the past, by 40 distributors in various countries... A new bulletin, No. 145, contains capsule descriptions of J.&H. Rotomotive equipment for aircraft—i.e., gas-turbine and reciprocating engine starters, inverters, generators, aircraft motors, actuators, alternators, tachometer generators, electrical control systems, and hydraulic equipment. Complete technical data on integrated electrical control systems for generators and alternators designed for aircraft and ground use are contained in Bulletin No. 1150-1. Both bulletins are available gratis.

• **Johns-Manville Corporation**... A four-page folder on Thermoflex Blankets, high-temperature thermal insulation for aircraft power plants and air frames, is now available. Slanted for personnel interested in the production of jet aircraft, the folder features the new Type K "inside-out" construction and the new Thermoflex RF (refractory fiber) Felt. The text covers pertinent subjects such as stability, weight, thermal transmittance, and fire resistance. It also includes tables of technical data and typical uses to help determine which type of Thermoflex Blanket construction is most suitable for a given application.

• **Walter Kidde & Company, Inc.**... The Civil Aeronautics Administration recently



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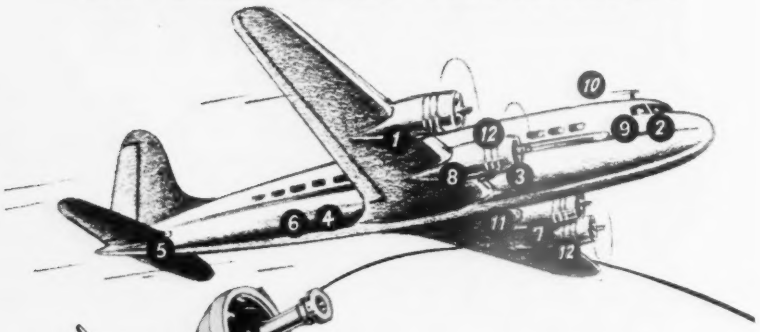
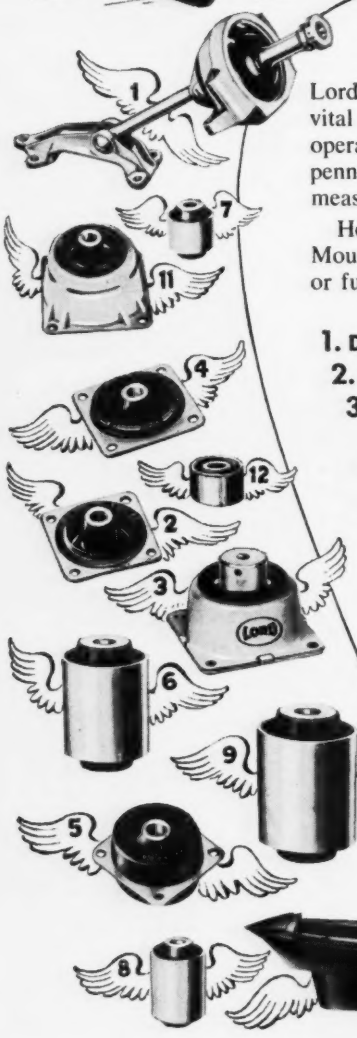
IMPROVE AIRCRAFT PERFORMANCE BY USING LORD MOUNTINGS!





Lord Mountings protect the service life of vital aircraft parts and improve the overall operation of aircraft. From engine to empennage, Lord Mountings contribute a full measure of dependability.

Here are but a few examples of Lord Mountings which may help you on present or future designs:

1. Dynafocal Engine Suspensions
2. Instrument Panel Mountings
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4. Engine Generator Mountings (For Flying Boats, for Ground Equip.)
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7. Cowl Mountings
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approved the installation in commercial aircraft of the Kidde Continuous Resetting Type Fire Detector. The equipment has also completed qualification tests by the U.S. Air Force and the Navy's Bureau of Aeronautics for use on military aircraft. This system, now in production, consists of a continuous wire-like fire-sensing element connected at one end to a monitoring control unit, which in turn provides the power for the system and the electronic circuit for actuating audible and/or visible alarms located on the pilot's instrument panel. The other terminal of the sensing element is connected to a relay circuit for pre-flight and in-flight testing. The electronic control unit is shock mounted and has been tested from −85° to 250°F. In over 2,000 hours of test flights, no false alarms have been recorded, while one fire was picked up.

• **Lear, Incorporated**. . .George K. Otis, who has been, and will continue as, General Manager of the LearCal Division, has been elected a Vice-President of the corporation.

• **Lockheed Aircraft Corporation**. . .The first production operations were started last January at Lockheed's new $400,000 hangar at Palmdale, Calif. The F-94 interceptors built at Burbank and Van Nuys, Calif., are being trucked to this section of desert, which has been tagged "Jetville, U.S.A.," for completion of assembly and flight. Later, the new planes will be flown to the desert plant for their test program. The value of Lockheed's installation at this location, which has been selected by the Air Force for a $30,000,000 jet center, is estimated at $12,500,000. This latter amount includes the present hangar and $850,000 worth of structures still to be built, all of which will ultimately be absorbed by the U.S.A.F.

• **Marman Products Company, Inc.**. . . The first complete catalog on V-Band Couplings has been released. This booklet is one of a series that, when completed, will cover the entire line of Marman clamping and fastening devices.

• **The Glenn L. Martin Company**. . .The first of Martin's two experimental XB-51 bombers was flown to Edwards Air Force Base, Calif., last January to undergo additional flight testing. Phase I and II Air Force flight tests were completed at Martin Airport in Baltimore, Md.

• **McDonnell Aircraft Corporation**. . . Robert H. Charles, Secretary and Director of McDonnell, was elected to a newly created position of Vice-President. Harper Woodward, A.M.I.A.S., New York Attorney, has resigned as a corporation Director.

• **North American Aviation, Inc.**. . . .The first Navy plane to be built at the Columbus (Ohio) plant rolled off the production line last January. The plane is the AJ-2P Savage, a photo reconnaissance version of the AJ-2. The new Savage carries 18 cameras only and is equipped for both day and night reconnaissance at high and low altitudes. For night reconnaissance, it carries special photo flash bombs in the bombay. Automatic control systems handle many of its camera installations. . . A new facility with over 9,400 sq.ft. of factory area has been leased in Culver City, Calif., in order to expedite production of

RYAN BRACKETS THE AIRCRAFT FIELD

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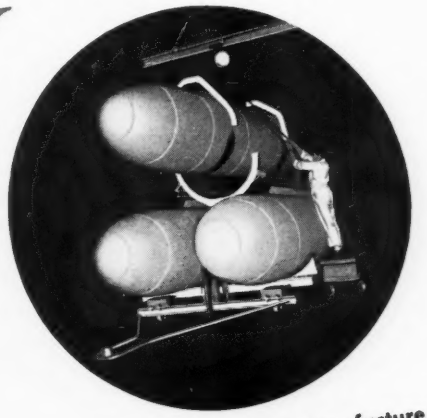
AIRCRAFT and AERONAUTICAL PRODUCTS



Airframe Components Manufacture
and Navion Executive-Liaison Airplanes

Electronics Research
and Development

Pilotless Aircraft
and Jet Propulsion Research

Ryan activities bracket many fields ranging from development of subminiature electronic equipment to manufacture of huge external fuel tanks and fuselage sections . . . from executive-liaison planes to high-speed pilotless jet aircraft and new applications of jet propulsion.

RYAN AERONAUTICAL COMPANY
LINDBERGH FIELD, SAN DIEGO, CALIFORNIA

precision machine parts for experimental work on automatic controls equipment. The work now being accomplished there is for the company's Electro-Mechanical Department.

• **Northrop Aircraft, Inc.**...An exclusive license to manufacture and distribute an improved type of zinc chromate primer for aluminum aircraft parts has been granted to The Sherwin-Williams Company. This new Northrop Seal Primer #75 was developed by Northrop's Process Engineering Department in cooperation with Sherwin-Williams' Aircraft Development Laboratories. Tests indicate that this seal primer has a high corrosion resistance... The F-89 Scorpion has successfully completed a series of spin tests. The tests were conducted at altitudes ranging from 21,000 to 30,000 ft.

• **The Parker Appliance Company**...New data sheets are available on hydraulic cone check valves for both 1,500- and 3,000-lbs. per sq.in. service, manufactured by Parker Aircraft Company. The sheets are available on request to The Parker Appliance Company, Cleveland.

• **A. V. Roe Canada Limited**...The company hopes to be in full occupation of the new gas-turbine plant at Malton, Ontario, by the middle of 1952...Fred T. Smye, a Director of the company, has become General Manager of the Aircraft Division. Mr. Smye formerly held the now nonexistent position of Executive Vice-President. The position of General Manager is a newly created one.

• **Sikorsky Aircraft Division, United Aircraft Corporation**...A licensing agreement has been signed with Aero du Sud-Est, Paris, France, for the French production of the 10-place S-55 helicopter. One other European firm, Westland Aircraft, Limited, England, also holds a license to build this helicopter.

• **Union Carbide and Carbon Corporation**...The construction of a major unit for the production of polyethylene resins is now under way as an addition to the Texas City plant of Carbide and Carbon Chemicals Company, a Division of U.C.C. This unit, which consists of three buildings on an 8-acre plot, is expected to be in production by early 1953. The polyethylene resin made in this new unit will be further compounded by companies such as Bakelite Company, another U.C.C. Division.

• **United Air Lines, Inc.**...Paul M. Godehn, Director of the company for 18 years, died in Chicago on January 31 after a 3-month illness. Mr. Godehn was a member of the legal firm of Mayer, Meyer, Austrian & Platt in Chicago.

• **Westinghouse Electric Corporation**... Final acceptance tests have been completed on a new Westinghouse-designed radio control for the 30-ft. 3,500-lb. lifeboat that is designed to be dropped by parachute from an aircraft. The electrical control system, by which the lifeboat is guided to survivors in the water, uses the radio signal from the air to control the engine and equipment for driving and steering the boat. This electrical system was designed around a radio transmitter-receiver set developed by the Wright Air Development Center, Wright-Patterson Air Force Base, Ohio...A new seven-page booklet, now available upon request, brings together the latest information on Micarta pulleys for aircraft. This booklet, B-4351, presents three general types, the AN "no-glow," the antifriction bearing, and special-type pulleys...Two vice-presidents were reassigned and an additional two were elected by a recent action of the Board of Directors. Reassigned were Tom Turner and T. I. Phillips. Mr. Turner, who was formerly Vice-President in charge of industrial relations and had the staff responsibility for headquarters manufacturing, was made Vice-President in charge of the Motor and Control Division. Mr. Phillips, formerly in charge of the East Pittsburgh Divisions, became staff Vice-President in charge of Manufacturing. Robert D. Blasier and John E. Payne are the newly elected vice-presidents. Mr. Blasier is now in charge of industrial relations and a member of the headquarters staff of the corporation's president. Mr. Payne was placed in charge of the company's central sales district.

THE WORLD'S NEWEST AIR LINER

Ready for flight testing and delivery to United Air Lines in March, the first production model of the Convair-Liner 340 is shown at the San Diego plant of Consolidated Vultee Aircraft Corporation. The 340 is equipped with full-feathering reversible Hamilton Standard propellers and two 2,400 hp. Pratt & Whitney CB-16 engines. It can carry 44 passengers, a crew of three or four, and 850 lbs. of cargo at a speed of approximately 300 m.p.h. It has a cruising range of more than 1,000 miles. United has 40 of these ships on order; deliveries will continue during 1952 and 1953.

• **Wright Aeronautical Division, Curtiss-Wright Corporation**...Turbo-Compound power plants are now being produced for the new Lockheed Super Constellations and the Douglas DC-7's. The first of the engines is scheduled for delivery sometime this spring.

Meet Your Section Chairman

Don O. Benson

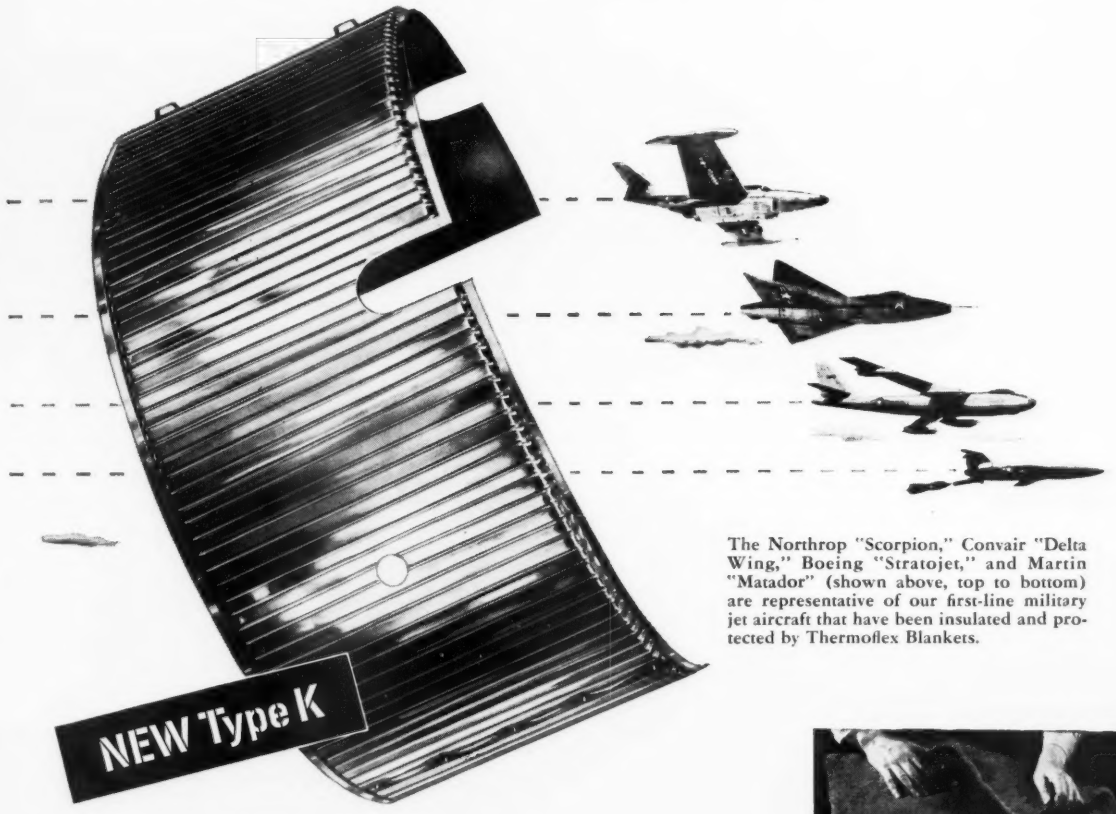
Twin Cities Section

Don O. Benson, a native son of Minnesota, has been with Northwest Airlines since he was graduated from the University of Minnesota's Institute of Technology in 1938 with a Bachelor's degree in Aeronautical Engineering. He was originally employed as an Aeronautical Engineer. In 1940, he was promoted to Superintendent of Line Maintenance and Service and 2 years later became Chief of Production Planning for a B-24 modification program. For several months in the winter of 1942-1943, he held the position of Coordinator of Maintenance Regulations.

When Northwest accepted a U.S.-A.A.F. contract for service testing and modification of the various types of military planes then in use, Mr. Benson was sent to the U.S.A.A.F. Accelerated Service Test Base at Vandalia, Ohio, as Production Superintendent. This was in the spring of 1943. At the termination of this contract about a year later, Mr. Benson was transferred to Northwest's St. Paul Modification Center No. 12 as Assistant Superintendent in charge of Production. A few months later, he was named Senior Project Engineer on Ice Research, a project operated by Northwest under contract to Air Materiel Command and in conjunction with N.A.C.A.

In December, 1944, Mr. Benson was appointed Superintendent of Aircraft Engineering, and last year he was pro-

On the latest Air Force and Navy aircraft...



The Northrop "Scorpion," Convair "Delta Wing," Boeing "Stratojet," and Martin "Matador" (shown above, top to bottom) are representative of our first-line military jet aircraft that have been insulated and protected by Thermoflex Blankets.

THERMOFLEX BLANKETS

insulate against searing heat of jet engines

JUST as the Air Force and Navy demand speed and maneuverability in their latest jet aircraft . . . they also demand safety factors such as are provided by Thermoflex* Blankets. These custom-made blankets insulate and protect both power plant and airframe against the searing heat of jet engines.

To keep pace with fast-changing requirements, Johns-Manville has recently developed a new engineering feature for Thermoflex Blankets. It is an "inside-out" construction known as Type K.

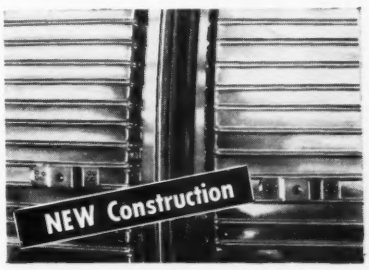
By reversing the former standard Thermoflex Blanket construction and placing the smooth foil on the *inside* and the grooved foil on the *outside* . . . tension on the inside foil permits a very snug fit. And the *entire blanket* expands circumferentially without crushing the insulation filler as the diameter of the tail pipe, exhaust cone, or afterburner expands with high temperatures.

Another major improvement in Thermoflex Blankets—made necessary by the extensive use of afterburners in jet engine design—is the new Thermoflex RF Felt. This lighter weight blanket insulation filler is made from fiberized, molten refractory minerals, and has exceptional stability at the high temperatures encountered in jet propulsion.

Thermoflex Blankets are also available in special preformed shapes to insulate, protect, and fireproof interior engine parts, heating systems, de-icing ducts, fluid storage tanks, and many other aircraft assemblies.

For further information, send for your copy of Brochure IN-136A. Address Johns-Manville, Box 60, N.Y.16, N.Y. In Canada, 199 Bay St., Toronto, Ontario.

Made of fiberized molten refractory minerals, this new, lighter Thermoflex Blanket insulation filler has exceptional stability at high temperatures. Note its flexibility.



Close-up view of new Type K Thermoflex Blanket construction with grooved foil on *outside*, smooth foil on *inside*. This permits circumferential expansion of *entire blanket* without crushing insulation filler.

*Reg. U. S. Pat. Off.

JOHNS MANVILLE PRODUCTS **Johns-Manville** **PRODUCTS for the AVIATION INDUSTRY**

AMPHENOL
Carries the Pulse
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. . . and if the cables and connectors in your equipment aren't of top quality, then the pulse will be weak and unreliable. Insist on Amphenol cables and connectors and be assured of maintained continuity and positive connection.
TEFLON CABLES developed by Amphenol are ideally suited for applications in the high temperature range. These cables operate without difficulty in temperatures from —100°F. to +450°F. They also feature extremely low loss and high voltage break down. Look to Amphenol for the entire series of RG Cables.
AUDIO CONNECTORS made by Amphenol are ruggedly built for severe usage and feature a unique watertight seal that provides full protection against water leakage. This type of connector is now standard on all Signal Corps communication equipment. Contacts are spring loaded and self-cleaning.
A-N CONNECTORS require a strict conformity to Army-Navy Specifications. Many of the now standard design features were originated and developed by Amphenol's extensive engineering staff. Amphenol's A-N Cable Assemblies provide the ideal combination of top quality components and high grade workmanship.
RF CONNECTORS are better if they are made by Amphenol—better because they are made better! Amphenol's RF Connectors have the quality and precision necessary in the most delicate and accurate of instruments, yet are rugged enough to meet the punishing demands of modern military aircraft and mechanized ground equipment.
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moted to his present position as Manager of Aircraft Engineering. In this capacity, he has the administrative and technical responsibility for all aircraft specifications and modifications.

Mr. Benson, who was born on February 28, 1915, in Fergus Falls where he received his secondary schooling, is married to the former Elaine Essen. Mr. and Mrs. Benson are the parents of two sons, Alan, aged 10, and Gregory, aged 8. For recreational purposes, Mr. Benson goes in for hunting, fishing, photography, raising unusual house plants, interior decorating, and landscaping.

Mr. Benson has served as a member of the N.A.C.A. Committee for Aircraft Construction, as well as on the Air Transport Association Aircraft Requirements Committee. He presented a paper on the "Safety Aspects of the Air Transport in 1955" at the 1948 National Aeronautic Meeting of the Society of Automotive Engineers.

I.A.S. Sections

Baltimore Section

M. Francis Taylor, *Secretary*

The meeting of January 22, which was held at The Johns Hopkins University, was called to order by Chairman F. D. Jewett with approximately 95 members and guests present.

There were three speakers of the evening: Otto Kirchner, Director of Operational Engineering, American Airlines System; Dr. Alphonse Chapanis, of Johns Hopkins University; and Hugh DeHaven, Director of Crash Injury Research, Cornell Medical Center. Mr. Kirchner spoke on "Lessons Learned from Accident Investigations"; Dr. Chapanis, on "Some Contributions of Applied Experimental Psychology to Problems of Aviation Safety"; and Mr. DeHaven, on "Passenger Protection in Abrupt Deceleration." Jerome Lederer, Director, Daniel and Florence Guggenheim Aviation Safety Center, Cornell University, was the Discussion Chairman of the three talks.

The first speaker, Mr. Kirchner, discussed safety from the air-line standpoint and pointed out that outstanding safety records are not achieved overnight but are the result of continuous development over the years. He emphasized that even more attention to possible hazards is required on the part of accessory manufacturers as, over the years, aircraft accessories have tended to grow more and more complicated. He emphasized that constant attention to safety considerations is required on the part of designers and engineers and pointed out that secondary failures are

often more serious than the primary ones. In conclusion, Mr. Kirchner reviewed changes being required by American Airlines to improve the safety of its new airplanes.

The second speaker of the evening was Dr. Chapanis, who pointed out that human error was the source of most aviation accidents. The psychologists who have been called in to assist in the solution of the accident problem have attacked the problem in three ways: (a) determining which operating personnel are accident prone; (b) training accepted personnel to improve safety habits; and (c) assisting the engineer in the design of accident-proof equipment. In discussing equipment, Dr. Chapanis dealt with the design of individual pieces as well as the grouping of equipment.

Dr. Chapanis' study of sources of near accidents through interviewing aircraft pilots indicates the following: (a) the most critical period appeared to be in the landing approach; (b) the second most critical hazard is the maze of switches and dials existings in the cockpit; (c) the third most frequent source of trouble is navigation error.

Dr. Chapanis summed up the psychologists' problem in relation to aviation accidents as an effort to help the individual to see better, hear better, and act with the least amount of indecision in carrying out assignments.

The third and final speaker of the evening, Mr. DeHaven, confined his remarks to the passenger-seat-facing problem. He suggested that all seats should face the same direction and that the public will accept the direction affording the maximum safety. He emphasized that not nearly enough is known about crash conditions, including loads developed, etc., and that, while bits of information are being accumulated continuously, it is still a bit early to set design limits for maximum safety based on sound engineering reasoning.

In conclusion, Mr. DeHaven noted that the two most amazing facts noticeable in his investigations of accidents are the ability of aircraft structures to absorb energy and the toughness of human beings.

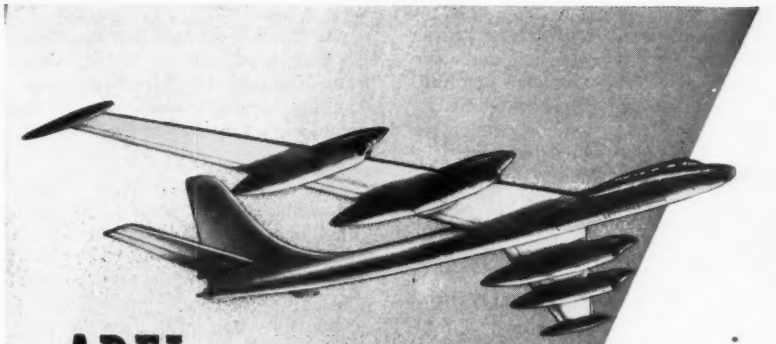
The meeting was adjourned at 10:30 p.m.

Buffalo Section

Alexander Krivetsky, *Secretary*

The January 16 meeting was held in the Empire State Room of the Hotel Statler with approximately 130 members and guests present. The meeting was held in conjunction with the Niagara Frontier Rocket Society.

The speaker was David A. Anderton, of *Aviation Week*, who spoke on "Atomic Energy for Aircraft Propulsion." Mr. Anderton discussed some of the basic



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WHATEVER your requirements, ADEL is the one manufacturer able to furnish aircraft hydraulic control equipment for every application. And from this complete ADEL line of controls you gain three distinct advantages.

You get first of all, unprejudiced recommendations about the control equipment best suited to your needs. You gain the benefit of ADEL'S fourteen years experience in all phases of hydraulic control. Finally, you can standardize on one source for all your aircraft hydraulic control equipment. This places full responsibility with one company.

Beyond these advantages of the only complete product line are ADEL'S comprehensive facilities for service, ingenuity in design development and engineering as well as precision and efficiency in manufacturing. So standardize on ADEL—the leader in completeness of line, service and dependable performance.

ADEL also manufactures a complete line of fuel heater and anti-icing accessories, and clips and line supports.

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definitions and principles of nuclear energy, some methods of harnessing the power for aircraft propulsion, and some of the engineering problems involved. The required characteristics of the fissionable fuel for a nuclear reactor are that it undergoes fission with ease, it is readily available, and its mining and processing costs are low. Uranium fills these requirements, and this metal is fairly abundant, contrary to common belief.

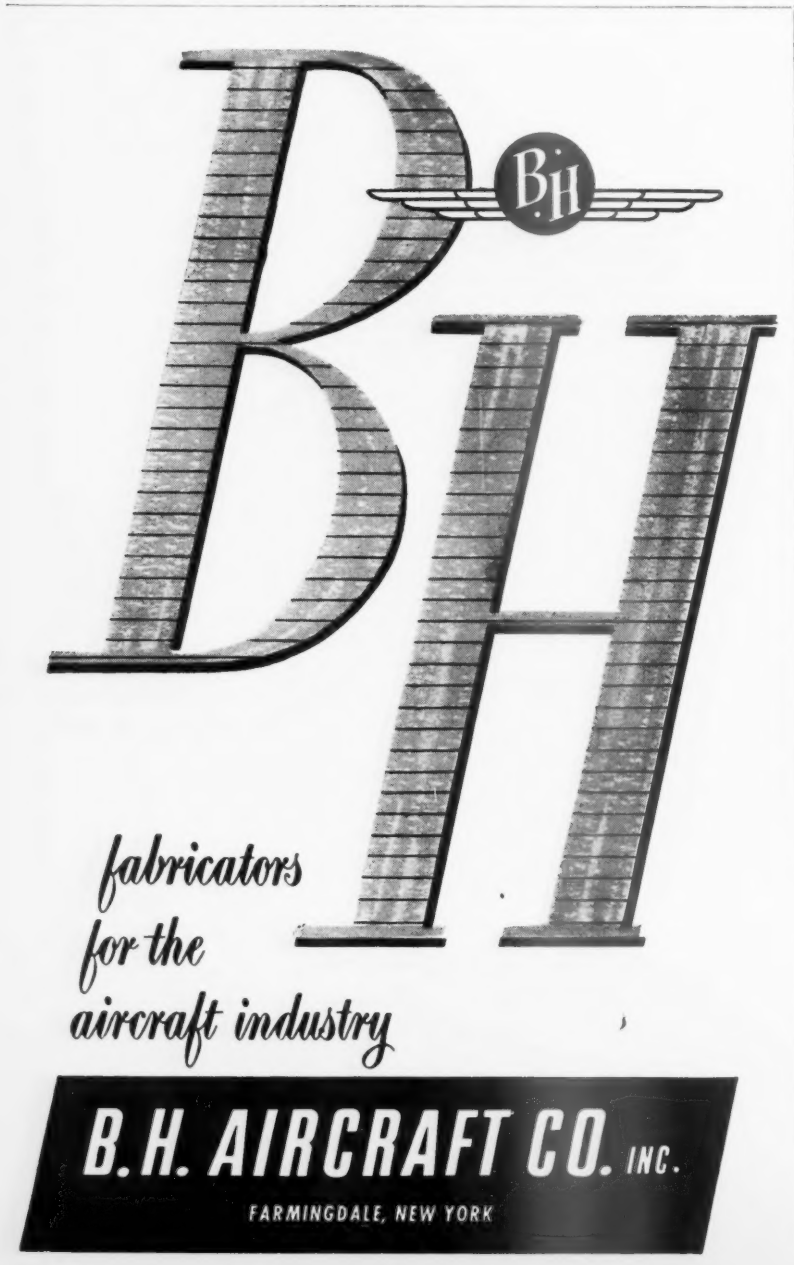
The construction of a portable reactor involves numerous engineering problems, some of which are yet unanswered. The material employed for the reactor must be capable of withstanding high temperatures and thermal stresses. It is also possible that mechanical properties may be affected by the bombardment of the high-energy particles. In addition, the material of the reactor should have a low capture rate for neutrons.

The fission process produces emissions and radiations that are fatal to man. Consequently, shielding becomes a problem that does not stop at the reactor, since the heat-transfer medium becomes radioactive by contamination from the reactor. The control of the fission process in the nuclear reactor is an important factor that can be accomplished by inserting or withdrawing an absorbing rod, thus decreasing or increasing the power levels. Such a system is not necessarily stable, and, since some neutrons are delayed in their fission process, a time lag results. Thus, the control of the absorbing rod does not produce instantaneous or quick power responses.

The aircraft designer has the problem of the installation of the power plant, whether it be nuclear ram-jet, turbojet, rocket, or turboprop and obtaining its energy from a slow or fast reactor. The design of a fast reactor has numerous drawbacks at present, such as high heat density wherein current available heat-transfer techniques are inadequate and neutrons escape more easily from a fast reactor that then requires more "fuel." However, the fast reactor is smaller and lighter. Because of the minute fuel consumption, the landing and take-off weights would be the same. This will impose severe landing-gear problems. The inertia load distribution would be entirely different from our present-day common aircraft because of the weight and density of the nuclear-powered airplanes.

In all probability, the first nuclear aircraft propulsion unit will be a slow reactor installed in a huge flying boat with a power plant of about 50 tons. The reactor and heat exchanger will be located deep within the hull surrounded by protective shielding. The time-lag problems of the system are such that a pilot cannot get immediate power increases or decreases. This time lag demands longer take-off and landing runs, for which the ocean is ideal. Crash safety is another item. A resulting crash would produce radioactive wreckage; the land area surrounding the crash would be impossible to approach for a long time. During its initial flights, the plane can be tested in the Pacific, and, in the event of an accident, the radioactivity would be confined and rapidly diluted so that danger to humans would be minimized. This has already been demonstrated by the experimental atom-bomb bursts.

The nuclear power plant can provide sufficient power from 0.007 lb. of fissionable uranium isotope to cover the distance of 25,000 miles. This 0.007 lb. would correspond to about 1 lb. of uranium.



Chicago Section

Alfred F. Stott, *Secretary*

The January 10 meeting was held on the campus of Illinois Institute of Technology. Twenty-seven attended a 6:30 dinner in the Student Union and 63 attended an 8:30 meeting. The meeting was called to order by Chairman Robert H. Wendt. Program Chairman Dr. H. L. Hull mentioned the future

meetings and then introduced John M. Wild, Acting Director of Engineering, ARO, Inc. He presented an excellent talk, accompanied by slides, on the Arnold Engineering Development Center, Tullahoma, Tenn. He pointed out the tremendous need for aeronautical research and development work and showed the lack of modern adequate test facilities. At present, the project will consist of three major test facilities—namely, Engine Test, Gas Dynamics, and Propulsion Wind Tunnel. The power requirements for this project are equivalent to those of a city of 200,000.

The first unit to go into operation will be the Engine Test facility. It will be capable of testing turbojet and ramjet engines and will have a capacity of six to eight times that of any existing facility. Atmospheric air will be compressed to flow at 300 to 500 ft. per sec., and altitude conditions will be simulated. Seventy-five thousand horsepower will be required to operate this unit.

The Gas Dynamic unit will be used for the development of supersonic aircraft and missiles. The Mach range will be from 1.2 to over 5.0 with a wide range of Reynolds Number. The test sections are 40 in. square. Ninety thousand horsepower is required to operate this unit.

The Propulsion Wind Tunnel for testing full-scale ram-jet or turbojet engines in aircraft or missiles will have a speed range from high transonic to well into supersonic. It will require 200,000 hp. to operate. The tunnel will have two sections, one transonic and the other supersonic. The test sections will be 16 ft. square and 30 ft. long. The air flow will be equal to the swallowing capacity of 350 F-80 fighters. Pressures can be simulated up to 75,000 ft. To provide cooling, water will flow at the rate of 100,000 gals. per min. The compressor and drive system will cost $20,000,000.

Mr. Wild did an excellent job in describing this project that will be so valuable to all, and this talk is recommended for other sections.

Detroit Section

Kenneth E. Smith, *Secretary*

The January 8 meeting was held at the Engineering Society of Detroit. The speaker for the evening was Dr Myron Tribus, Director of Icing Research, University of Michigan. His subject was "Trends in Aircraft Ice Prevention Equipment."

Dr. Tribus discussed the history of the development of modern ice-prevention equipment, some of the technical problems in thermodynamics and aerodynamics associated with icing phenomena, and the future prospects in store for coping with this serious problem.

Several slides were shown which illustrated the occurrence of icing. The data resulting from experimental work were presented, and there were described certain experimental techniques that may lead to a more complete quantitative understanding of the icing process and the measures required for icing prevention.

San Diego Section

H. L. Braasch, *Secretary*

The regular December dinner meeting was held jointly with the San Diego branch of the Society of Automotive Engineers at 7:00 p.m. on December 4 in the House of Hospitality, Balboa Park, San Diego.

There was a brief social hour preceding the dinner, and the meeting was called to order by Herb Sharp, Chairman of the S.A.E. San Diego branch. Mr. Sharp paid tribute to the joint efforts of the meeting's Chairmen, Harry Metteson (I.A.S.) and Phil Ward (S.A.E.), and introduced Bill Heath, Chairman of the I.A.S. San Diego Section.

Mr. Heath introduced the speakers of the evening, Frank W. Fink, Chief Engineer, Consolidated Vultee Aircraft Corporation, and Paul A. Pitt, Chief

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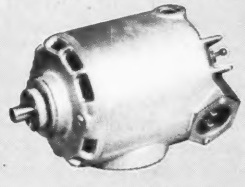

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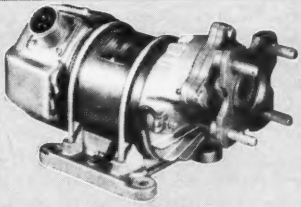

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Development Engineer, Solar Aircraft Company, who recently returned from the joint I.A.S.-R.Ae.S. meeting in Brighton, England, and from the S.B.-A.C. show at Farnborough, England.

Mr. Fink spoke first concerning British air-frame manufacture. With a series of slides, he pointed out recent design trends in both commercial and military aircraft and presented pictures of the latest developments in all types of British air-frame design. Mr. Fink discussed methods of construction used in England and pointed out several successful experimental aircraft that, due to limited facilities, have not become production aircraft.

Mr. Pitt discussed the late developments of British aircraft engines. Through the presentation of a series of slides, he illustrated the basic details of their new designs and gave performance comparisons of the power plants both in production and in development stages. Mr. Pitt pointed out that the trend in the development of new engines is toward the more efficient axial-flow compressors in preference to the centrifugal-flow type.

At the conclusion of Mr. Pitt's talk, a motion picture taken by E. Stout, Convair, of the exhibits at the S.B.A.C. show at Farnborough was shown. The picture included various ground displays of British aircraft and a portion of the flight demonstrations. Mr. Fink acted as narrator.

At the conclusion of the picture, the meeting was adjourned.

▶ The regular January dinner meeting was held at 7:00 p.m. on January 17 at the Henry Langhorst Cafe in San Diego. As W. C. Heath, Section Chairman, was unable to attend, Dwight Bennett, Area Councilor Nominee, acted as Chairman pro tem.

The San Diego Section was honored to have as speaker for the evening Rear Adm. J. J. Clark, U.S.N., who spoke on the subject, "The Navy's Part of the War in Korea." Having spent some time in that area during recent operations, Admiral Clark was able to give first-hand information. Admiral Clark has served with the Navy in both World Wars and has had a wide range of experience in Naval Aviation operations. He was a Carrier Task Group Commander in World War II and participated in many actions against the Japanese from the central Pacific to Okinawa and the Japanese home islands.

Admiral Clark stated that the Navy and the Air Force have parallel jobs in the Korean war. Naval aircraft have been covering the eastern half of Korea, while the Air Force covers the western half. One of the primary missions has been the bombing of transportation facilities, particularly railroads and bridges.

Admiral Clark stated that the AD and F4U type of aircraft are best suited for close air support, because of the relatively large bomb load that they are capable of carrying. The MIG type aircraft, which have been used by the enemy, are Russian planes that have been loaned for the primary purpose of obtaining information to be used in the further development of Russian aircraft and bombing techniques.

Following the talk, the meeting was adjourned by Mr. Bennett.

Texas Section

Charles L. Seacord, Jr., *Secretary*

The December 12 meeting, which was held in the American Legion Hall, Grand Prairie, Tex., featured an address by Dr. J. M. Frankland, of Chance Vought Aircraft Division, United Aircraft Corporation. Dr. Frankland, who is Technical Assistant to the Chief of Structures, chose as his subject, "The Strength of Aircraft Structures Under Repeated Loading."

The field of structural fatigue was reviewed in general as a preface to the particular subject of steel undergoing repeated stress reversals. Dr. Frankland then discussed in detail the results of recent work by R. J. Peterson, of Westinghouse Labs, and H. J. Grover, of Battelle Institute. It was pointed out in conclusion that in the present state of the art it is extremely difficult to make accurate theoretical estimates of the life of any aircraft part that is subject to cyclic stresses.

Following the talk, there was a discussion period during which Dr. Frankland and D. A. Redwine, Consolidated Vultee Aircraft Corporation, reviewed fatigue problems that have occurred on various Chance Vought and Convair airplanes. It was noted that in almost all cases of lightly loaded surfaces adhesive-bonded structure has shown greater resistance to fatigue than riveted structure.

Toronto Section

S. L. Britton, *Secretary*

The December 13 meeting was held in the new Mechanical Building of the University of Toronto. The speaker for the evening was R. J. Woods, Chief Design Engineer, Bell Aircraft Corporation, whose topic was "Some Problems of Trans-Sonic Aircraft Design." The meeting, which was attended by 141 members, was brought to order by Chairman H. D. Luttman, who gave a brief summary of the forthcoming elections. The chairman then turned the meeting over to C. V. Lindow, who introduced Mr. Woods and gave the membership a detailed description of the past accomplishments of Mr. Woods, telling of the many problems in supersonic flight research in which Mr. Woods has been involved.

Mr. Woods started his discussion by listing the requirements that must be met in the design of a transonic and supersonic aircraft. He then thoroughly discussed each of the requirements, showing how they could be met and, wherever possible, what the trends would be in future designs.

He explained how the criterion used in the past in establishing structural requirements for high-speed aircraft had been based on the terminal-velocity dive down to 12,000 ft. pressure altitude, with a limited *g* pull-out, but this basis had to be abandoned with the advent of the jet aircraft with its high-level flight speed. He explained that the angles of sweepback greater than 45° permitted higher level flight speeds at low altitudes, but that at altitude the aircraft with the straight wing had a decided stability advantage. He also explained how greater sweepback brought about higher horizontal tail loads and presented, at high speeds, considerable structural and pilot-control problems. He also reviewed the problem of providing satisfactory aileron effectiveness at high speed, giving descriptions "without divulging actual data" of how the pilot reacts to the various conditions and effects of high-speed flight. He reviewed the miscellaneous high-speed problems brought about by the addition of drag brakes that are required for rapid decelerations for maneuvering in combat or slowing down the aircraft to land. He also described some of the complexities of the electronic installations which were brought about by the use of radar and automatic gun sights, made necessary by high-speed flights.

Mr. Woods explained the need for control-booster systems potent enough to meet the maximum stick-force requirement for the worst condition and yet delicate enough so as not to eliminate the "feel" required to carry out high-altitude flying and landing. Mr. Woods stated "that a new concept of transonic and low supersonic speed-control and stability studies are needed, augmented by as much free-flight investigations as possible, to endeavor to rationalize the available aircraft flight parameters with the idealistic concept of aerial combat tactics. Further, much additional work is necessary to crossbreed the aiming devices, Fire Control Computer, radar search and track, and air-to-air missiles, which have been 'cooked-up' with the aircraft's actual flight characteristics to produce an effective weapon."

After the conclusion of this most enjoyable and informative talk, the speaker permitted questions to be asked by the members present. During one

of these discussions, the advantages and disadvantages of the flying-wing and the delta-wing aircraft were discussed, answering a great many of the problems that apparently were in the minds of the members.

The meeting was adjourned at 11:15 p.m. by the chairman after C. F. Mathews had thanked Mr. Woods for a most educational and enjoyable evening.

▸ The annual general meeting of the Toronto Section was held on January 16 in the "Chez Paris" dining room. In all, 91 members and guests were in attendance, which represented a large percentage of the members who are normally active in this section.

Chairman Luttman presided over the dinner, which had been preceded by a cocktail hour. The names of the newly elected officers for 1952 were read by C. V. Lindow as follows: Chairman, K. M. Molson; Vice-Chairman, S. L. Britton; Secretary, R. T. Gibson; and Treasurer, R. G. Halford. The new officers were introduced.

After the business meeting was completed, three films were shown. They were: *Screaming Jets* (courtesy of A. V. Roe Canada Limited), *Flight Log* (courtesy of Shell Oil Company), and *The NATIV* (courtesy of North American Aviation, Inc.).

The chairman officially adjourned the meeting at 11:00 p.m.

Student Branches

University of Alabama

Dr. August Raspet, of the Mississippi State College, spoke on "Boundary Layer Control for Sailplanes" at the January 10 meeting. Chairman William E. Carr presided; 16 persons were present.

Carnegie Institute of Technology

On January 15, Prof. Clarence Mallory Tyler, Head, Aeronautical Option Department, Carnegie, spoke to the 25 assembled students on the subject of "Opportunities for Aeronautical Engineers This Year." Chairman Carl Zorowski presided.

University of Cincinnati

At the January 14 meeting, an election of officers for the second semester was held with the following results: Chairman, Dale A. Benethum; Vice-Chairman, Donald Hoak; Secretary, Donald Johnson; and Treasurer, Armand Charest. Donald C. Ballentine was the acting Chairman for this meeting; 24 persons were present.

▸ On January 21, a film, *Battle for Tunisia*, was shown. Chairman Benethum presided; 28 were in attendance.

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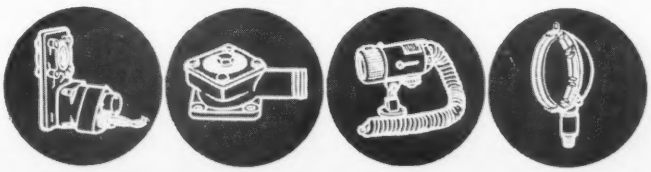

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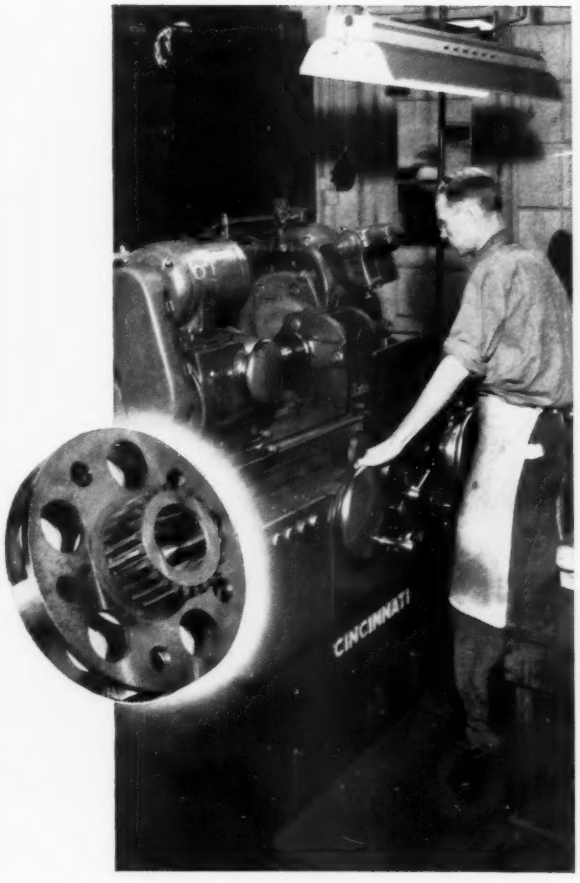

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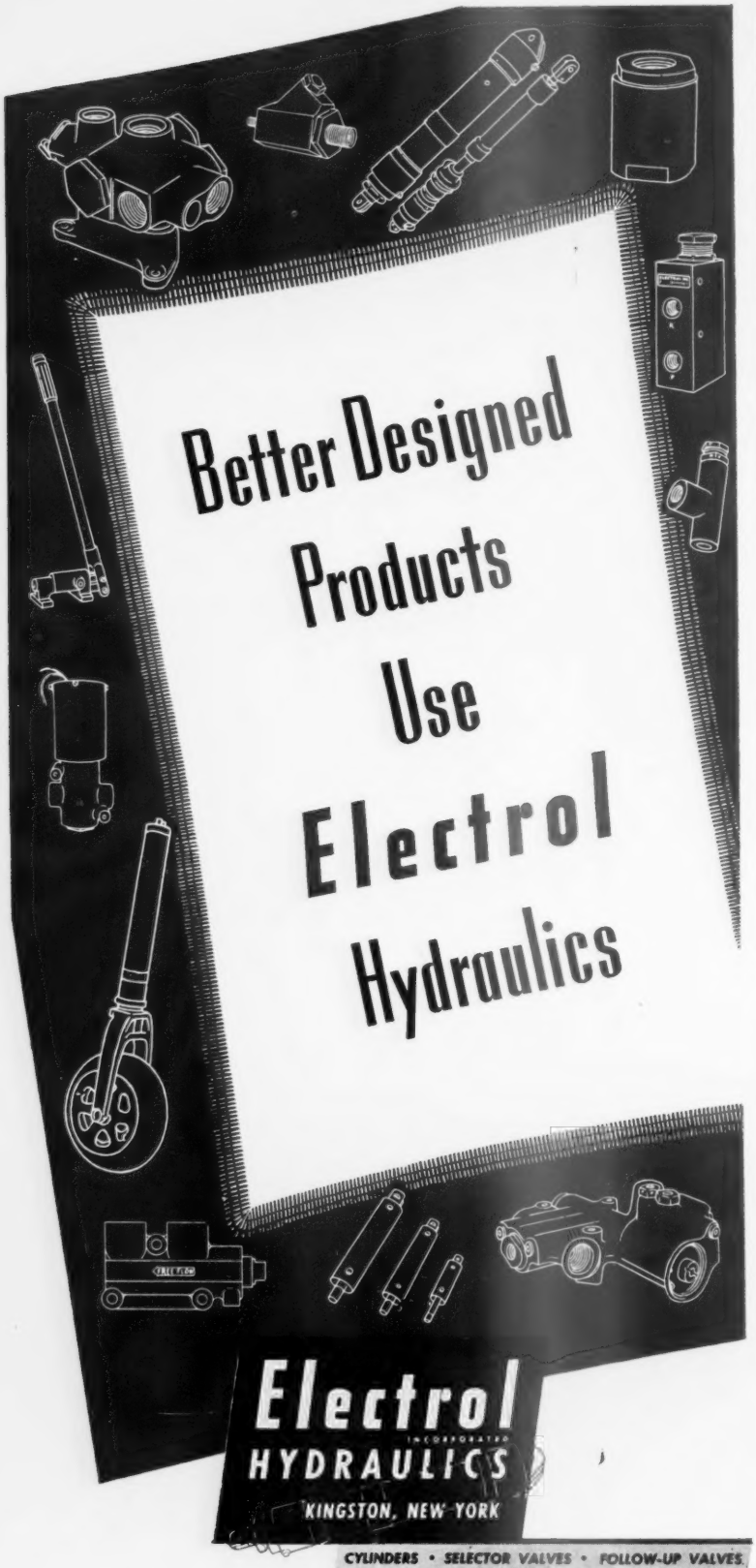

▶ Professor Bradley Jones, Head of the Aeronautical Engineering Department of the university, introduced Dr. Raymond Walters, President of the university, at the January 28 meeting. Dr. Walters spoke briefly on the position of aeronautics in the present world and then presented the Weston Awards, which are given annually at the University of Cincinnati to promote the scientific development of aeronautics. The first prize of $125 went to Frank Laacke, while John Doner received the second prize of $100. Chairman Benethum presided; 25 students were present.

University of Colorado

Professor Franklin P. Durham of the university's Aeronautical Engineering Department, spoke on "Rocket Nozzle Tests." The meeting was held on January 9 with Chairman Burt R. Benson presiding. Eight persons were present.

Georgia Institute of Technology

The new officers are: Chairman, George O. Kelbert; Vice-Chairman, Wesley Mann; Secretary, Paul Nichols; and Treasurer, William Schleich.

University of Illinois

The following students were elected to office for the second semester at the January 9 meeting: Chairman, Loran Anderson; Vice-Chairman, Don Pfeuffer; and Secretary-Treasurer, Gordon D. Booz. At the conclusion of the business meeting, a film, *Battle of Britain*, was shown. Chairman Bill Greenfield presided; 24 students were present.

Indiana Technical College

A film, *Construction of the Piper Cub*, was shown at the January 10 meeting. Chairman John W. Whitehurst presided; 10 persons were present.

▶ The meeting of January 24 was called to order by Vice-Chairman George S. Greeneberg. Mr. Whitehurst, branch Chairman, spoke to the ten attending persons on the subject, "Rockets and Interplanetary Travel."

Kansas State College of Agriculture and Applied Science

The following students were elected to serve as officers for the 1952 spring semester: Chairman, Harold Osborn; Vice-Chairman, John Lederer; Secretary-Treasurer, Marvin Smith. The election took place at the January 17 meeting, which was attended by ten persons.

University of Notre Dame

On January 11, Student Members Wayne Six and Leighton Johnson spoke

on the subjects of "Deicing" and "Design Problems of the X-1," respectively. This being the last meeting of the semester, an election of officers was held with the following results: Chairman, Robert Sebold; Vice-Chairman, William Flick; Secretary, Thomas Lindsay; and Treasurer, Raymond Fredette. The Engineering Advisory Board Representative is Charles Stalzer. The meeting was concluded with the showing of a film on lift. Chairman Peter Skerret presided; 18 persons were present.

The Ohio State University

On January 9, W. S. Edwards, Design Standards Group, Columbus Division, North American Aviation, Inc., spoke on "Standards in the Aircraft Industry." Chairman Richard G. Dicken led the meeting at which 21 were present.

Syracuse University

The January 9 meeting was called to order by Chairman Jack Andrews with 9 members present. An election of officers for the spring semester was held, and those elected are as follows: Chairman, Spence Weller; Vice-Chairman, Bob Walsh; Secretary, Dave Birdseye; and Treasurer, Vincent Sherman.

Agricultural and Mechanical College of Texas

On January 9, 20 persons were present to hear C. E. Neyland, Senior Aerodynamicist, Fort Worth Division, Consolidated Vultee Aircraft Corporation, speak on "The Reduction of Flight Test Data." The talk was followed by a motion picture, *Target for Peace.* Chairman Richart T. Cliffe presided.

Tri-State College

A motion picture entitled *Combustion* was shown at the January 24 meeting at which Chairman Jack Jewell presided. Twenty-seven persons were present.

United States Naval Academy

On December 7, the tenth anniversary of the the Pearl Harbor attack, a film entitled *Road to Hawaii* was shown to the Brigade of Midshipmen. The attendance at this film, which gave the Japanese version of Pearl Harbor, was in excess of 350. Chairman S. McNeely, Midshipman 1/c, presided.

▸ A film, *Identification of Russian Aircraft,* was shown at the December 14 meeting at which Midshipman McNeely presided. Twenty-one persons were present.

▸ On January 11, under the chairmanship of Midshipman McNeely, a film, *Gliding Wings,* was shown. Fifty-nine persons were present.

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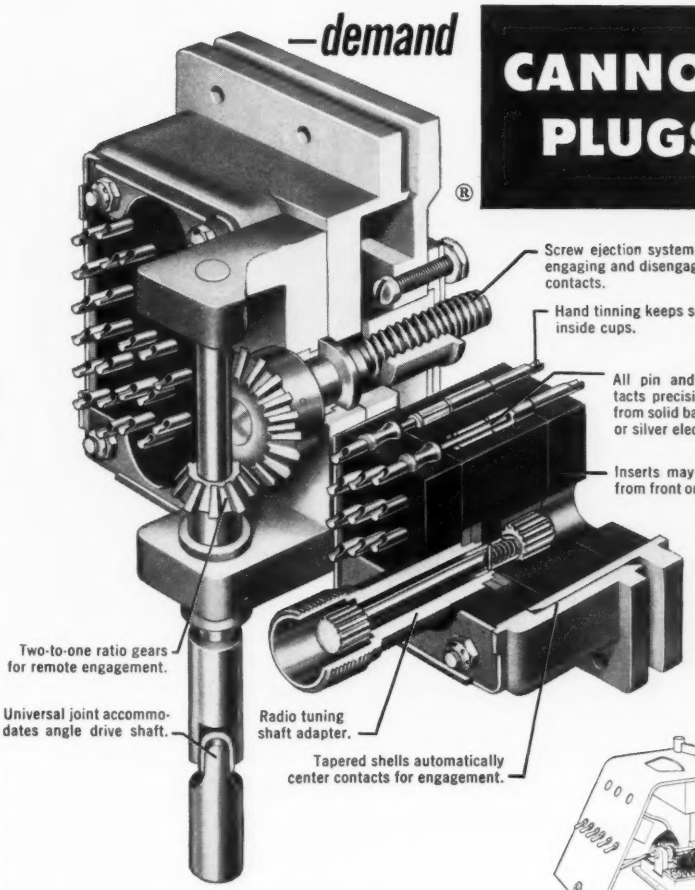
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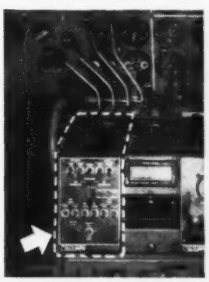

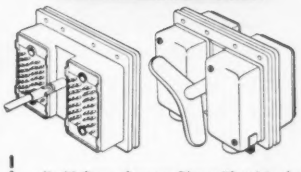

(Left) Same Cannon Plug without tuning shaft. Straight drive instead of 90° gear. (Right) Similar DPD2 with Dzus wing nut extraction method and junction shells. There are several other variations. Write for details.

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Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Skinner, Selby M., Ph.D. (Physics), Chief Scientist, Office of Scientific Research, Hq., Air Research & Development Command, U.S.A.F. (Baltimore).

Transferred to Associate Fellow Grade

Weichsel, Hans, Jr., B.S. in Ae.E., Sales Engineer & Demonstration Pilot, Bell Aircraft Corp.

Elected to MEMBER Grade

Baker, Ronald J., B.S.M.E., Supervisor, Flight Engineering & Flight Test Scheduled Air Transport, Trans-Canada Air Lines.

Bedell, Donald W., B.S. in Ch.E., Aviation Coordinator, Esso Standard Oil Co.

Dewey, David B., Jr., A.A., Engineering Draftsman & Aerodynamics Engineer, Consolidated Vultee Aircraft Corp.

Diehl, Richard A., Dipl. Ing., Power-Plant Design Engineer, Douglas Aircraft Co., Inc. (Santa Monica).

Gillies, John A., B.A.Sc., Tech. Asst. to the Mgr. of Aviation Sales, Imperial Oil, Ltd.

Grummann, Herbert R., A.M., Assoc. Prof., Aero. Engineering, Parks College of Aero. Technology.

Hermann, Theodore, B.S., Project Engineer, Benson-Lehner Corp.

Justice, Donald A., B.S. in M.E., Project Engineer, Marquardt Aircraft Co.

Knerr, Hugh J., Major General, U.S.A.F. (Ret.); Executive Vice-President, Air Lifts, Inc.

Louie, Harry, M.S., Standards Engineer, Canadair, Ltd.

Martin, Charles P., M.S. in M.E., Aero. Power Plant Engineer, Wright Air Development Center, U.S.A.F.

Rivers, William H., B.S. in E.E., Aerodynamicist—Special Facilities, Sverdrup & Parcel, Inc.

Robbins, Herbert S., B.S., Mgr., West Coast Office, Propeller Div., Curtiss-Wright Corp.

Seaborn, Earl B., B.S., Engineering Designer "B," Engineering Dept., Douglas Aircraft Co., Inc. (Santa Monica).

Snyder, Lee G., B.S., President, American Electroneering Corp.

Transferred to MEMBER Grade

Bitondo, Domenic, Ph.D. in Ae.E., Research Engineer, Aerophysics Development Corp.

Carnese, Daniel J., B.S., Sr. Aerodynamicist, Piasecki Helicopter Corp.

Drell, Harry, B.S. in M.E., Aerodynamics Engineer, Thermodynamic Section, Lockheed Aircraft Corp.

Peabody, Prentice B., Major, U.S.A.F.; Research Development Officer, Guided Missiles, Holloman Air Force Base (N.M.).

(*Continued on page 98*)

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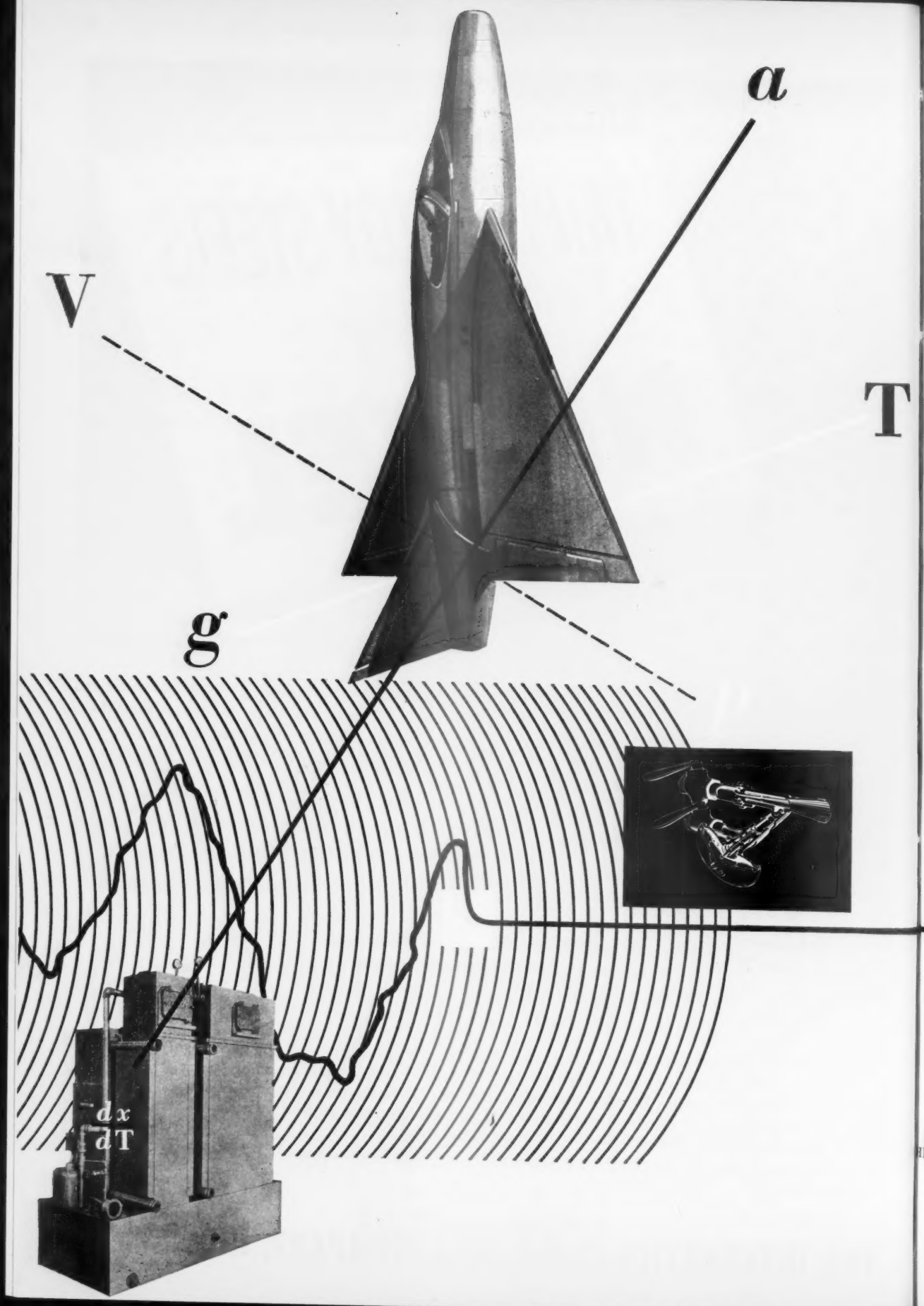
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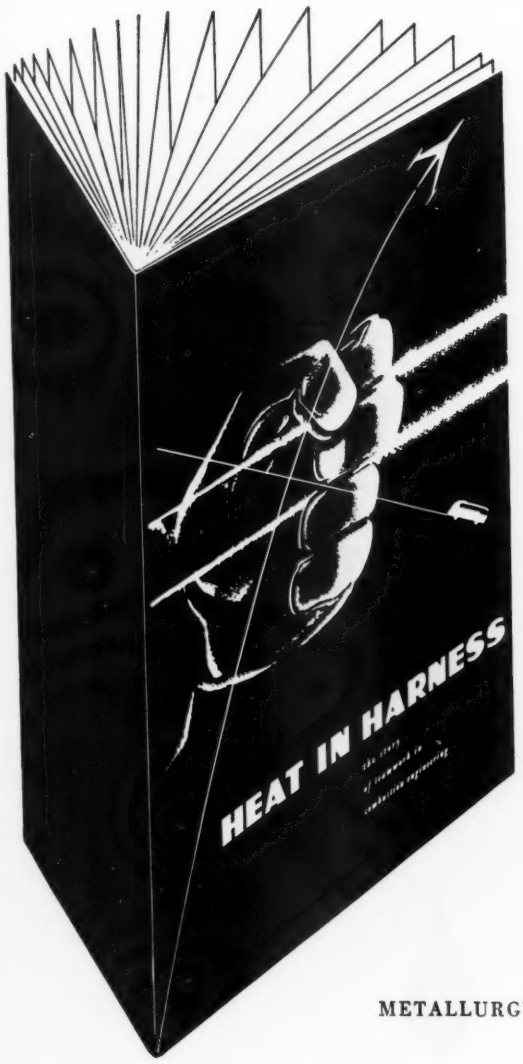

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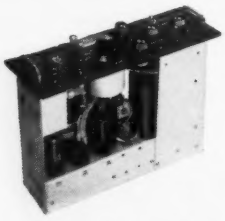

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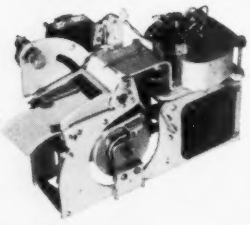

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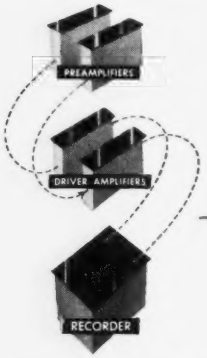
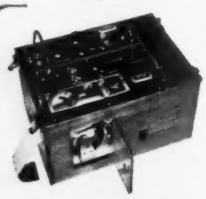


Any of the recording channels in the three systems at the right may include *either* a Strain Gage or General Purpose Amplifier, or the latter in combination (in 2-, and 4-channel systems) with either AC or DC Preamplifiers. For, any of the Amplifiers or Preamplifiers provided for in a system may be quickly *removed* from its place in the system and as quickly *replaced* with an alternate type.



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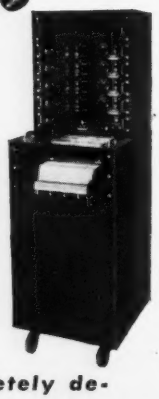

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Losee, John E., Service Engineer, Republic Aviation Corp.

Transferred to Associate Member Grade

Gonnerman, La Verne William, B.S., Captain & Academic Instructor, U.S.A.F.

Elected to Technical Member Grade

Curtis, Harold S., B.S., Engineering Designer "B," Douglas Aircraft Co., Inc. (Long Beach).

Duitman, Rock, A.A., Mathematician, Douglas Aircraft Co., Inc. (Santa Monica).

Dunlap, R. Alan, M.S.E., Aerodynamicist, Douglas Aircraft Co., Inc. (Santa Monica).

Habermass, Zbigniew, Asst. Development Engineer, Fireproof Tanks, Ltd.

Jaillard, Paul E., A.E., Purchasing Agent, Commercial Dept., Breguet Aircraft Co. (Paris).

Jupiter, Clyde P., M.S. in Physics, Research Aerodynamicist, Douglas Aircraft Co., Inc. (Santa Monica).

O'Connor, Maurice A., Jr., B.S., Power-Plant Engineer, Douglas Aircraft Co., Inc. (Santa Monica).

Sparks, Leonard K., Jr., B.S., Mathematician, Douglas Aircraft Co., Inc. (Santa Monica).

Totman, Robert E., B.S., Power-Plant Engineer, Douglas Aircraft Co., Inc. (Santa Monica).

Transferred to Technical Member Grade

Barrial, Harold J., B.S. in Ae.E., New-design Engineer, The Glenn L. Martin Co.

Boxer, Martin, B. of Ae.E., Test Engineer, Wright Aero. Div., Curtiss-Wright Corp.

Carroll, Thomas J., Flight Test Data Analyst, Special Weapons Div., Northrop Aircraft, Inc.

Cosby, James F., B.S., Structural Test Engineer, The Glenn L. Martin Co.

Deem, Ralph E., M.S., Mathematician "A," Aerodynamics Group, Performance Section, Douglas Aircraft Co., Inc. (Long Beach).

Donohue, William J., Jr., B.S., 2nd Lt., U.S.A.F.; Student Pilot, 3308th Tng. Sq., Kinston Air Base.

Elder, Clarence L., M.S. in Ae.E., Lt. Colonel, U.S.A.F.; Ch., Plans Office, Operations Branch, 6540th Missile Test Wing, Holloman Air Force Base (N.M.).

Ferguson, Mona, B. of Ae.E., Aero. Engineer—Aerodynamics Research, United Aircraft Corp. (East Hartford).

Field, Robert E., Rocket Test Mechanic, Flight Test Center, U.S.A.F., Edwards Air Force Base.

Frayer, Robert G., B.S.M.E. (Aero.), Mathematician—Aerodynamics, Douglas Aircraft Co., Inc. (Santa Monica).

Geller, Edward S., B. of Ae.E., Aero. Research Intern, GS-5, N.A.C.A. (Langley Air Force Base).

German, Richard C., B.S. (Aero.), 2nd Lt., U.S.A.F.R.; Project Engineer, ADC, Wright-Patterson Air Force Base.

Hawk, G. Wayne, B.S., Lt., U.S.A.F.; Research & Development Officer, Thermodynamics Section, Gas Dynamics Branch, Engineering Div., Arnold Engineering Development Center. (Tullahoma).

Horney, Ernest E. J., B.A.Sc. in Ae.E., Project Engineer, Fleet Mfg. Ltd. (Ft. Erie).

Horvath, Michael A., B.S. in Ae.E., Engineering Design Draftsman, Douglas Aircraft Co., Inc. (Santa Monica).

Hull, Ralph L., B.S., Jr. Engineer, Boeing Airplane Co. (Wichita).

Johnson, Russell L., B. of Ae.E., Test Engineer, General Electric Co.

Kelley, Robert P., B. of Ae.E., Major, U.S.A.F.; Logistics Plans Asst., ADC, Ent Air Force Base (Colo.).

Kirk, Jack L., M.S., Field Service Rep., Boeing Airplane Co. (Wichita).

McClymonds, James C., B.S., Mathematician "A," Stress Analysis Group, Douglas Aircraft Co., Inc. (Long Beach).

McInnes, Paul, B.S. in Ae.E., Lt., U.S.N.; Engineering Officer, Bureau of Aeronautics Representative (Akron).

McLaren, Don, B.A.Sc., Scheduler, Planning Office Group Leader, De Havilland Aircraft of Canada, Ltd. (Downsview).

Moyles, John A., B.A.Sc., Flight Cadet, R.C.A.F. (Centralia, Ont.).

Nadworny, Henri C., B. of Ae.E., Engineering Draftsman "B," Structures Group, Douglas Aircraft Co., Inc. (Santa Monica).

Putland, Leonard W., B. of Ae.E., Aero. Aerodynamics Research Intern, N.A.C.A. (Langley Air Force Base).

Rohr, Arthur P., B.S., Aerodynamic Engineer, North American Aviation, Inc. (Columbus).

Sandstrom, Clair K., B.S. in Ae.E., Engineering Draftsman, North American Aviation, Inc. (Columbus).

Schulte, Orville J., Lt. Colonel, U.S.A.F., Ch., Systems Branch, Plans Office, Hq., Rome Air Development Center (Griffiss Air Force Base).

Simonin, Laverne D., B.S. (Aero.), Tool Designer, Stress Group, Boeing Airplane Co. (Wichita).

Sivier, Kenneth R., B.S.E. (Aero. & Math.), Engineering Trainee, ARO, Inc.; assigned to Naval Ordnance Lab., Silver Spring.

Smith, Howard W., B.S. in Ae.E., Jr. Engineer "A," Stress Unit, Boeing Airplane Co. (Wichita).

Stevens, Robert O., B.S.E., Test Engr. Wright Aero. Div., Curtiss-Wright Corp.

Studer, Vincent J., B.S.E. (Aero.), Jr. Engineer, Structures Group, Consolidated Vultee Aircraft Corp. (Ft. Worth).

Unick, Charles J., B.S. in Ae.E., Design Draftsman, Goodyear Aircraft Corp.

Voss, William R., B.S. in Ae.E., Captain, U.S.A.F.; Officer in Charge—Engine & Aero. Repair Sections, Walker Air Force Base (N.M.).

Waller, Charles S., M.S., Captain & Sr. Pilot, U.S.A.F.; Project Engineer, Research & Development, Wright-Patterson Air Force Base.

Whiteway, Roger E., B.S., Technical Writer, Consolidated Vultee Aircraft Corp. (Ft. Worth).

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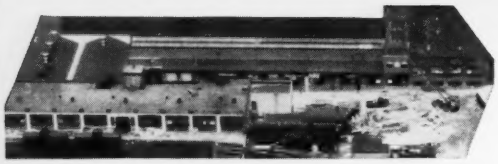

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Aerodynamics (2)

BOUNDARY LAYER & THERMOAERODYNAMICS

The Boundary Layer in Three Dimensional Flow. L. Howarth. *Philosophical Magazine*, Vol. 42 (7th Series), No. 335, December, 1951, pp. 1433–1440. 5 references.

Equations for the boundary-layer flow in the vicinity of a stagnation point on a three-dimensional surface are reduced to a pair of simultaneous ordinary third-order differential equations containing a single parameter determined by the mainstream flow. The variation of this parameter is limited to the range from 0, corresponding to two-dimensional flow, to 1, corresponding to the axial flow past a body of revolution; solutions are presented for the three values of the parameter in this range.

Note on the Boundary Layer on a Rotating Sphere. L. Howarth. *Philosophical Magazine*, Vol. 42 (7th Series), No. 334, November, 1951, pp. 1308–1315, illus. 4 references.

An approximate solution, using spherical coordinates, for the boundary-layer equations for the flow around a rotating sphere; limitations of the solution; importance of the curvature terms in the three-dimensional boundary-layer equations. The appendix considers the flow due to a semi-infinite cylinder rotating in a uniform stream.

Note on the Effect of Boundary-Layer Suction on Separation. E. V. Watson. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2538*, 1951 (May 9, 1947). 2 pp., illus. British Information Services, New York. $0.25. Analysis of the general character of the flow over a porous surface near a separation point, based on physical considerations.

Application of the von Kármán Momentum Theorem to Turbulent Boundary Layers. Jerold M. Bidwell. *U.S., N.A.C.A., Technical Note No. 2571*, December, 1951. 25 pp., illus. 17 references.

Studies of von Kármán's Similarity Theory and Its Extension to Compressible Flows; A Similarity Theory for Turbulent Boundary Layer over a Flat Plate in Compressible Flow. C. C. Lin and S. F. Shen. *U.S., N.A.C.A., Technical Note No. 2542*, November, 1951. 38 pp. 23 references.

Studies of von Kármán's Similarity Theory and Its Extension to Compressible Flows; Investigation of Turbulent Boundary Layer over a Flat Plate in Compressible Flow by the Similarity Theory. S. F. Shen. *U.S., N.A.C.A., Technical Note No. 2543*, November, 1951. 42 pp., illus. 12 references.

CONTROL SURFACES

Deceleron—A Feature of the F-89 Scorpion Control System. Boyd Richardson. *Aeronautical Engineering Review*, Vol. 11, No. 3, March, 1952, pp. 34–36, 56, illus. Design, performance, and efficiency of the deceleron speed brake. The brake is integrated into the aileron and controlled by a lever in the cockpit through a separate system.

Air Brakes. Robert McLarren. *Aero Digest*, Vol. 63, No. 6, December, 1951, pp. 30–32, 34, 36, 38, 42, 44, 46, illus. 9 references. Design and application of split-flap, wing-spoiler, and fuselage-panel air brakes to American, British, Canadian, and German jet aircraft.

FLUID MECHANICS & AERODYNAMIC THEORY

Resistance of a Place in Parallel Flow at Low Reynolds Numbers. Zbynek Janour. (*Prague, Letecký Výzkumný Ústav, Aeronautical Research Institute, Report No. 2*, 1947.) *U.S., N.A.C.A., Technical Memorandum No. 1316*, November, 1951. 40 pp., illus. 16 references.

Results of measurements in an oil channel of the resistance of a flat plate placed parallel to the flow, over a range of Reynolds Numbers from 10 to 10^3; comparison with values calculated from the Blasius formula.

Determination of Shapes of Boattail Bodies of Revolution for Minimum Wave Drag. Mac C. Adams. *U.S., N.A.C.A., Technical Note No. 2550*, November, 1951. 20 pp., illus. 6 references.

Determination of the minimum-wave-drag body profiles for boattail bodies having a given length and a given base area with (1) maximum area, (2) a given volume, and (3) a contour that passes through a given point between the nose and the base, using an approximate equation for the wave drag of slender bodies of revolution in supersonic flow.

Viscosities of Air and Nitrogen at Low Pressures. Herrick L. Johnston, Robert W. Mattox, and Robert W. Powers. *U.S., N.A.C.A., Technical Note No. 2546*, November, 1951. 22 pp., illus. 10 references.

Measurements of the apparent viscosities of air and of nitrogen at 306°K. and at 273°K. over the pressure range 0.0005 to 500 mm. Hg and at 194°K. and at 79°K. down to pressures of 0.3 mm. Hg.

On the Foundations of Certain Theories of Turbulence. M. Z. v. Krzywoblocki. *Franklin Institute, Journal*, Vol. 252, No. 5, November, 1951, pp. 409–412. Foundations and limitations of modern theories of turbulence, based on the hydrodynamics equations.

INTERNAL FLOW

Concerning the Flow About Ring-Shaped Cowlings of Finite Thickness. I. Dietrich Küchemann. **II.** Dietrich Küchemann and Johanna Weber. (*ZWB, Forschungsbericht, Nos. 1236, 1236/2*, June 13, November 11, 1940.) *U.S., N.A.C.A., Technical Memorandums Nos. 1325, 1326*, January, 1952, November, 1951. 24, 39 pp., illus. 7 references.

I. A procedure for obtaining the forms of ring-shaped bodies from tables of functions, following the method of superposition of flow due to singularities and parallel flow, and neglecting circulation; forms, pressure distributions, and inlet conditions of annular source bodies with and without hub bodies. **II.** Extension to flow including circulation; analysis of bodies of infinite length with approximately smooth entrance.

An Investigation by the Hodograph Method of Flow Through a Symmetrical Nozzle with Locally Supersonic Regions. F. Edward Ehlers and Hirsh G. Cohen. *U.S., N.A.C.A., Technical Note No. 2547*, November, 1951. 61 pp., illus. 19 references.

STABILITY & CONTROL

Lateral Control with High Lift Devices. A. D. Young. **Appendix.** R. R. Duddy. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2583*, 1951 (May, 1941). 36 pp., illus. 43 references. British Information Services, New York. $2.00. Summary of information on the characteristics and methods of using high-lift devices for lateral control which can be used with full-span flaps and with nearly full-span flaps.

Stability and Control Characteristics of a Complete Airplane Model Having a Wing with Quarter-Chord Line Swept Back 40°, Aspect Ratio 2.50, and Taper Ratio 0.42. Marvin Schuldenfrei, Paul Comisarow, and Kenneth W. Goodson. *U.S., N.A.C.A., Technical Note No. 2482*, December, 1951. 86 pp., illus. 6 references.

WINGS & AIRFOILS

An Experimental Investigation into the Suitability of a Corrugated Construction Wing for a Laminar-Flow Aerofoil. J. C. King. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2530*, 1951 (January, 1945). 25 pp., illus., folding charts. 4 references. British Information Services, New York. $2.10.

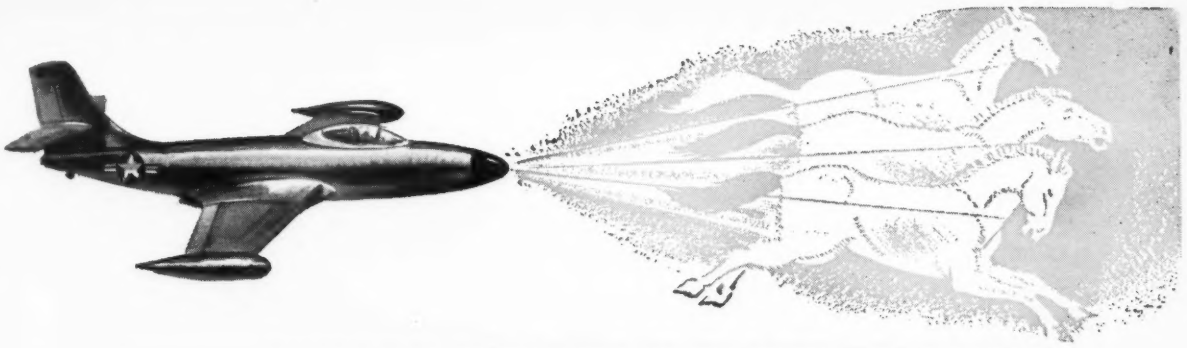
Structural considerations in the design of a laminar-flow airfoil; results of tests on a 6-ft. chord wing specimen having a thick skin reinforced by spanwise corrugations; aerodynamic efficiency of the wing.

The Incompressible Potential Flow Past Two-Dimensional Airfoils with Arbitrary Surface Suction. W. T. Lord. *Gt. Brit., Aeronautical Research Council, Current Papers No. 56*, 1951 (June 20, 1950). 44 pp., illus. 6 references. British Information Services, New York. $2.40.

Investigation of the potential flow past an airfoil that is not designed specifically for use with suction but which has an arbitrary distribution of suction over its surface. The analysis is carried out for the case of the unit porous circle, and the flow past the airfoil obtained from the conformal transformation of the circle into the airfoil.

An Experimental Investigation of Transonic Flow Past Two-Dimensional Wedge and Circular-Arc Sections Using a Mach-Zehnder Interferometer. Arthur Earl Bryson, Jr. *U.S., N.A.C.A., Technical Note No. 2560*, November, 1951. 97 pp., illus. 34 references.

A Velocity-Correction Formula for the Calculation of Transonic Mach Number Distributions over Diamond-Shaped Airfoils.



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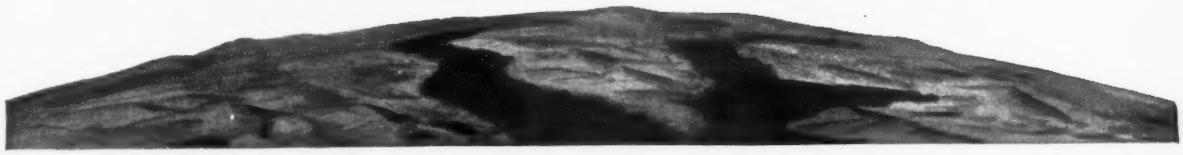

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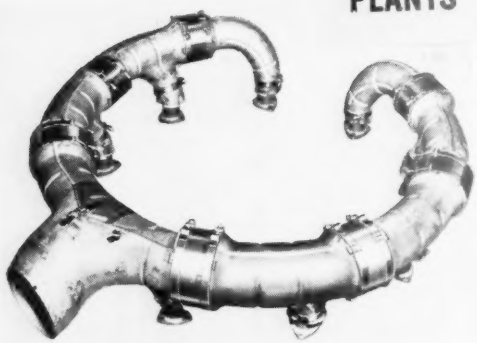

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H. Reese Ivey and Keith C. Harder. *U.S., N.A.C.A., Technical Note No. 2527*, November, 1951. 28 pp., illus. 5 references.

Free Flight Measurements at Supersonic Speeds of the Drag of a Particular Delta Wing Having a Simple Pressure Distribution. P. J. Herbert. *Gt. Brit., Aeronautical Research Council, Current Papers No. 57*, 1951 (November, 1950). 11 pp., illus. 4 references. British Information Services, New York. $0.50.

Tests at $R = 7.0 \times 10^6$ on a 45° round-nosed sweptback delta wing that has a root thickness/chord ratio of 0.6, using ground-launched rocket-boosted models; comparison with wind-tunnel data on a wing of similar section.

Theoretical Aerodynamic Characteristics of a Family of Slender Wing-Tail-Body Combinations. Harvard Lomax and Paul F. Byrd. *U.S., N.A.C.A., Technical Note No. 2554*, November, 1951. 75 pp., illus. 10 references.

Analysis of the aerodynamic coefficients of a configuration that consists of a nearly constant chord flat sweptback wing and a flat triangular horizontal tail mounted on a cylindrical body; the tail is located aft of the wing trailing edge.

Experimental Investigation of the Low-Speed Static and Yawing Stability Characteristics of a 45° Sweptback High-Wing Configuration with Various Twin Vertical Wing Fins. Alex Goodman and Walter D. Wolhart. *U.S., N.A.C.A., Technical Note No. 2534*, November, 1951. 25 pp., illus. 6 references.

Effect of Taper Ratio on the Low-Speed Rolling Stability Derivatives of Swept and Unswept Wings of Aspect Ratio 2.61. Jack D. Brewer and Lewis R. Fisher. (*U.S., N.A.C.A., Research Memorandum No. L8H18*, 1948.) *U.S., N.A.C.A., Technical Note No. 2555*, November, 1951. 17 pp., illus. 6 references.

Aeroelasticity

The Response of an Aerodynamic System Under External Harmonic Force. H. Serbin. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1307–1315, illus. 6 references.

Presentation of the theory of nonconservative linear systems of a finite number of degrees of freedom; derivation of the harmonic response function. The analysis makes use of the flutter type of aerodynamic coefficients by considering the behavior of the system under a sinusoidal forcing function. The analysis is extended to cover the effect of small changes in the parameters (perturbation theory), and to assess the effects of an additional degree of freedom. Calculation methods are presented and illustrated by solving the two-dimensional, three-degrees-of-freedom case.

The Response of a Simple Flexible Aeroplane to Gusts of Various Forms. F. H. Hooke. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. SM. 170*, August, 1951. 44 pp., illus. 8 references.

Analysis of the response of a simple flexural airplane to a sharp-edged and a linear gust, including an assessment of lift-lag effects. The response to an arbitrarily shaped gust can be obtained by representing the gust as a series of steps and adding the responses.

Application of Response Function to Calculation of Flutter Characteristics of a Wing Carrying Concentrated Masses. H. Serbin and E. L. Costilow. *U.S., N.A.C.A., Technical Note No. 2540*, November, 1951. 52 pp., illus. 5 references.

Theory and application of the method of the harmonic response function to the effect on flutter of the attachment of a rigid mass to an airplane having n degrees of freedom. The rigid body is idealized first as a point mass, then as a distributed mass.

Evaluation of High-Angle-of-Attack Aerodynamic-Derivative Data and Stall-Flutter Prediction Techniques. Robert L. Halfman, H. C. Johnson, and S. M. Haley. *U.S., N.A.C.A., Technical Note No. 2533*, November, 1951. 154 pp., illus. 12 references.

Measurement and evaluation of the aerodynamic forces on wings oscillating harmonically in pitch and translation in the stall range; correlation with previous data; development of a semiempirical method for predicting pitching moment variation with airfoil shape, frequency, initial angle of attack, and amplitude of oscillation.

Expressions for the Rates of Change of Critical Flutter Speeds and Frequencies with Inertial, Aerodynamic, and Elastic Coefficients. G. H. L. Buxton and I. T. Minhinnick. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2444*, 1951 (September, 1945). 71 pp., illus. 12 references. British Information Services, New York. $4.25.

Derivation of general formulas for the rate of change of critical speeds and frequencies with the inertia, aerodynamic, and elastic coefficients, and of special forms of the equations for binary flutter The formulas can be used to estimate the effect of a small change in one or more of the coefficients, thus showing the sensitivity of the flutter speeds and frequencies to the various coefficients. The forms of the equations are presented for the cases when structural and artificial damping terms are included.

Numerical Determination of Indicial Lift of a Two-Dimensional Sinking Airfoil at Subsonic Mach Numbers from Oscillatory Lift Coefficients with Calculations for Mach Number 0.7. Bernard Mazelsky. *U.S., N.A.C.A., Technical Note No. 2562*, December, 1951. 38 pp., illus. 11 references.

Predominately Subharmonic Oscillations. Carl A. Ludeke. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1321–1326, illus. 6 references.

Investigation, using an electromechanical analog, of the phenomena of subharmonic oscillations in which the subharmonic component predominates; transitions between subharmonics of different orders.

Air Transportation (41)

Air Transport in New Zealand and the South Pacific. Leonard Isitt. (7th British Commonwealth and Empire Lecture, October 4, 1951.) *Royal Aeronautical Society, Journal*, Vol. 55, No. 491, November, 1951, pp. 699–723. A statistical and operational appraisal of passenger and freight air transport in New Zealand and the South Pacific.

Some Practical Experience with Civil Jet Transport Operation and Associated Meteorological Problems. A. C. Campbell Orde. *Aeronautical Engineering Review*, Vol. 11, No. 3, March, 1952, pp. 47–54, illus.

Effect of meteorological factors on the economy of jet aircraft operations; analysis of methods of determining fuel reserves; evaluation of the meteorological and related communications services required by increased operating speeds and cruising altitudes on typical long-haul operations; B.O.A.C. operating experience with the Comet I.

Growing Use Seen for Two-Engine Planes. F. Lee Moore. *Aviation Week*, Vol. 55, No. 24, December 10, 1951, pp. 71–74, llus., tables.

Comparison of the operating costs of modern two- and four-engined transport aircraft (Convair 240, 340; Douglas DC-6, -6B) on scheduled air-line routes; advantages of twin-engined aircraft on short-haul (less than 500 miles) flights.

The Accidental Carriage of Insects on Board Aircraft. Marshall Laird. *Royal Aeronautical Society, Journal*, Vol. 55, No. 491, November, 1951, pp. 735–743. 38 references. Comparison of ships and aircraft as accidental carriers of harmful insects; techniques of prevention and control in aircraft.

Airplane Design (10)

The Aircraft Standards of the S.B.A.C.; A Complete List of the Sheets and Reference Sheets Contained in the Society's Standards Handbook. *Aircraft Engineering*, Vol. 23, No. 273, November, 1951, pp. 339–346.

Civil Turbine Transport Riddle. *Aero Digest*, Vol. 63, No. 6, December, 1951, pp. 17–19, illus. Findings and recommendations of the Foreign Survey Group of the C.A.A.'s Prototype Aircraft Advisory Committee.

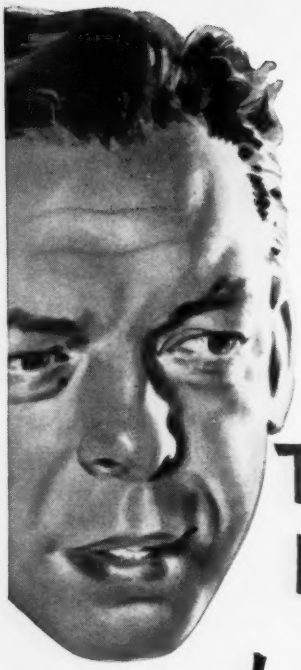
AIRPLANE DESCRIPTIONS

Finland's Military Aircraft. *Flight*, Vol. 50, No. 2238, December 14, 1951, pp. 749, 750, illus. Design and performance of Finnish fighter aircraft; production problems.

Fighting Breed; Forty Years of Sopwith and Hawker Aircraft. H. F. King. *Flight*, Vol. 60, No. 2236, November 30, 1951, pp. 677–696, illus. Historical background of Sopwith and Hawker fighter aircraft; production and performance data on current models.

Aeronca Type 7AC Champion Single-Engined Lightplane. *The Aeroplane*, Vol. 81, No. 2106, November 30, 1951, pp. 712, 713, illus. Equipped with the Munk variable-pitch, one-piece propeller.

Auster B.4 Single-Engined Ambulance-Freighter Aircraft, England. *The Aeroplane*, Vol. 81, No. 2107, December 7, 1951, pp. 728–731, illus., cutaway drawing.



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Béarn Minicab Two-Place Trainer Personal Aircraft, France. *Flight*, Vol. 60, No. 2235, November 23, 1951, pp. 644, 645, illus.

Blackburn and General Aircraft Four-Engined Universal Freighter, England. *The Aeroplane*, Vol. 81, No. 2105, November 23, 1951, 665–671, illus. Structural data, possible military applications, and performance graphs.

Douglas DC-7 Four-Engined Transport Aircraft. *American Aviation*, Vol. 15, No. 34, January 21, 1952, pp. 16, 17, illus.

Gloster G.A.5 Delta-Wing, Long-Range All-Weather Radar-Equipped Turbojet Fighter Aircraft, England. *Flight*, Vol. 60, No. 2237, December 7, 1951, pp. 712, 713, illus.

Martin 4-0-4 Twin-Engined Transport Aircraft. *Aviation Week*, Vol. 55, No. 23, December 3, 1951, p. 68, illus. Electrically driven linear-type actuator to adjust the position of the horizontal stabilizer on the Martin 4-0-4.

Northrop F-89 Scorpion Two-Engined Turbojet Fighter. Boyd Richardson. *Aeronautical Engineering Review*, Vol. 11, No. 3, March, 1952, pp. 34–36, 56, illus. Design, performance, and efficiency of the deceleron speed brake.

SIPA S.12 Single-Engined Trainer Aircraft, France. *Flight*, Vol. 60, No. 2238, December 14, 1951, pp. 752, 753, illus.

SIPA S.902 Two-Place Trainer Aircraft, France. *Flight*, Vol. 60, No. 2234, November 16, 1951, pp. 616–618, illus.

TEMCO T-35 Buckaroo Trainer Aircraft. *Aero Digest*, Vol. 63, No. 6, December, 1951, pp. 20–27, illus., cutaway drawing.

BODY GROUP

Recent Development in Methods of Strength Testing Pressurized Fuselages. A. W. Hotson. *Royal Aeronautical Society, Journal*, Vol. 55, No. 491, November, 1951, 724–734, illus.

Experimental comparison of the advantages and disadvantages of techniques in which air pressure is used to test the strength of pressurized fuselages with a technique that uses water; plans for future tests combining pressure with external loading.

Reduction of Gun-Gas Explosion Hazard in Combat Aircraft. J. J. Horan, J. R. Onderdonk, and E. Witkin. *Aeronautical Engineering Review*, Vol. 11, No. 3, March, 1952, pp. 37–43, illus.

Construction of a gas-detection device for investigating explosibility of residual gases in the gun compartment of combat aircraft; criteria for air-frame designers; methods of eliminating explosions.

LANDING GEAR

Tires Are "Landed" at 240 Miles per Hour. *U. S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 12, December, 1951, p. 13, illus. Design and structural aspects of tire casings that reduce blowout hazards; use of a dynamometer to simulate aircraft tire landings at speeds up to 240 m.p.h.

Airports (39)

Pittsburgh's Super Airport to Open April 1. Richard Fuller. *American Aviation*, Vol. 15, No. 32, January 7, 1952, pp. 21, 22, illus. Terminal-building facilities and approach lighting system at Greater Pittsburgh Airport.

Group Urges Standard Visual Aid. *Aviation Week*, Vol. 55, No. 22, November 26, 1951, p. 69, illus. Ground markers and threshold lighting for instrument runways, proposed by I.A.T.A. Flight Technical Group.

Aviation Medicine (19)

The Human Factor in Instrument Design. Lynn S. Beals, Jr. *Instruments*, Vol. 24, No. 11, November, 1951, pp. 1290, 1291, 1337–1339, illus. 15 references. Analysis of the psychological, medical, and anthropological factors involved in the design of instrument dials and control knobs; general philosophy of functional instrument design.

Human Control Systems. Frederic Bartlett. *Society of Instrument Technology, Transactions*, Vol. 3, No. 3, September, 1951, pp. 134–140, Discussion, pp. 140–142, illus. 9 references.

Analysis of human control systems and their implications in instrument design and operation. The systems are considered to be a behavior pattern in which the operator is using streams of information from a variety of sources as a check to produce bal-

anced response; anticipation, immediate recall, and remote memory of the human operator are involved.

Passengers, Pilots, and Psychology. *Flight*, Vol. 60, No. 2236, November 30, 1951, pp. 700–701, illus. The pilot's role in arranging for the mental and physical comfort of his passengers.

Comfortization (23)

Water Systems in Civil Aircraft. C. H. Cumberland and G. S. Bowey. *Aircraft Engineering*, Vol. 23, No. 273, November, 1951, pp. 322–329, illus. 4 references.

Factors involved in the layout, design, and efficiency of water supply systems for passenger use in civil aircraft; design standards based on current practices in Great Britain; diagrams of U.S. and British installations. An appendix gives the B.O.A.C. standard for the treatment of water supplies for aircraft.

Education & Training (38)

F-86D Sabre Flight Simulator. Frank Coleman. *American Helicopter*, Vol. 24, No. 11, October, 1951, pp. 11–13, illus.

North American's all-weather electromechanical trainer that duplicates in detail the cockpit of the F-86D Sabre. Analog computers automatically adjust cockpit instruments to conform to actual flight conditions.

Meteorological Examinations for Civil Pilots and Navigators. A. F. Crossley. *Meteorological Magazine*, Vol. 80, No. 953, November, 1951, pp. 318–323. General and meteorological requirements prescribed for licensing crews of aircraft registered in the United Kingdom.

Electronics (3)

ANTENNAS

General Theory of Symmetric Biconical Antennas. S. A. Schelkunoff. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1330–1332, illus. 4 references. Determination of the input admittance of a symmetric biconical antenna of arbitrary angle.

The Necessary Number of Elements in a Directional Ring Aerial. H. Lottrup Knudsen. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1299–1306, illus. 9 references. Analysis of the dependence of the array characteristics of a directional ring aerial on its number of elements.

The Measurement of Current Distributions Along Coupled Antennas and Folded Dipoles. T. Morita and C. E. Faflick. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 12, December, 1951, pp. 1561–1565, illus. 4 references.

Complementary Filter Permits Antenna Sharing. *Electronics*, Vol. 24, No. 12, December, 1951, pp. 140, 142. illus.

Construction of a filter that allows two pieces of electronic equipment, with respective frequency ranges of 157–212 megacycles and 225–400 megacycles, to share the same antenna. The filter consists of separate low-pass and high-pass sections, each with a cutoff frequency of 218.5 megacycles.

Automatic Impedance Matcher. Virgil True. *Electronics*, Vol. 24, No. 12, December, 1951, pp. 98–102, illus. A device that automatically matches the input impedance of a 35-ft. whip antenna to a 50-ohm coaxial transmission line at all frequencies between 2 and 18 megacycles.

Simplified Antenna Pattern Plotting. J. K. MacDonald. *Electronics*, Vol. 24, No. 12, December, 1951, pp. 114, 115, illus. 2 references.

A graphic method that uses a single set of curves to plot horizontal patterns for two-tower antenna arrays with arbitrary spacing and phasing; extension of the method to systems of three or more towers. The reverse of the procedure is used to determine the spacing and phasing required to locate maximums and minimums at predetermined angles.

An Aural Homing Antenna Pattern Range. Walter R. Fried. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 16, No. 12, December, 1951, pp. 14–21, illus.

Theory and operation of an aural antenna model range that simulates, with a high degree of accuracy, the operation of lobe-switched, phased, aural homing adapters. A maximum reduction of stray reflections was achieved by using copper-sheet models, an acoustic telemetering system, and optimum construction and range location.

NBS Model Antenna Range. *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 35, No. 12, December, 1951, pp. 173–175, illus.

Design, operation, model techniques, and range of investigations of the N.B.S. model antenna range at Sterling, Va. The range is designed to measure antenna radiation patterns in the vertical plane in the 1 to 25 megacycle range.

CIRCUITS & COMPONENTS

Modified Locked-Oscillator Frequency Dividers. Peter G. Sulzer. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 12, December, 1951, pp. 1535–1537, illus. 18 references.

Details of a simple locked-oscillator frequency divider. The circuit, consisting of an *LC* oscillator modified to facilitate locking, is capable of operating over a 7-to-1 plate-supply-voltage range when dividing by a factor of 30.

Multivibrator Frequency Divider. R. R. Rathbone and R. L. Best. *Radio & Television News*, Vol. 46, No. 6, December, 1951, *Radio-Electronic Engineering*, pp. 6, 7, 29, illus.

Circuits and operation of an instrument that is a pulse generator with an output range of 200 kc. to 60 cycles; it can be synchronized with a frequency equal to or greater than the output frequency.

Transient Response; Conditions for Monotonic Characteristics. I. F. Macdiarmid. *Wireless Engineer*, Vol. 28, No. 338, November, 1951, pp. 330–334, illus. 5 references. Derivation of the conditions for monotonic transient response for networks having two poles and two zeros in the complex-frequency plane.

RC-Coupling Network for Pulse Transmission; Criteria for Maximum Pulse Sharpness. Hilary Moss. *Wireless Engineer*, Vol. 28, No. 338, November, 1951, pp. 345–349, illus. 1 reference.

Determination of Input Impedance and Other Properties of Networks. E. Green. *Marconi Review*, Vol. 14, No. 103, 4th Quarter, 1951, pp. 141–155, illus. 3 references. Formulation of expressions for the input impedance and input admittance of networks in terms of known frequency responses.

Discussion on "The Problem of a Non-Ohmic Resistor in Series with an Impedance" by E. B. Moullin. D. B. Corby and A. C. Sim. **Author's Reply.** *Institution of Electrical Engineers, Proceedings, Part I, General*, Vol. 98, No. 114, November, 1951, pp. 344–346, illus. 3 references.

The Loading Error in Linear Potentiometers. G. M. Parker. *Electronic Engineering*, Vol. 23, No. 286, December, 1951, p. 489, illus. Charts for determining the deviation from linearity of single-ended and push-pull potentiometers.

Improving the Sensitivity of Switches with Linear Feedback. J. J. Baruch. *Electrical Engineering*, Vol. 70, No. 12, pp. 1100–1104, illus. Methods of improving the sensitivity of switches by using a linear feedback coefficient; analysis of the nonlinear system with feedback; optimum systems.

Transistor Circuit Design. Gordon Raisbeck. *Electronics*, Vol. 24, No. 12, December, 1951, pp. 128–131, 134, illus. 1 reference.

Explanation of the duality technique for deriving amplifiers, oscillator, modulator, and multivibrator transistor circuits from known vacuum-tube circuits. The technique is also used to find transistor circuits corresponding to any complex vacuum-tube circuit.

A High-Power Toroidal Output Transformer. *General Radio Experimenter*, Vol. 26, No. 6, November, 1951, pp. 5–7, illus. 5 references.

Design and performance of the General Radio Type 942-A Output Transformer for coupling push-pull output tubes to a voice coil or other low-impedance load. The transformer handles peak powers up to 100 watts; eighteen impedance ratios from 4.42 to 1650 are obtainable.

Letters to the Editor: A Note on the Partial Differential Equations Describing Steady Current Flow in Intrinsic Semiconductors. R. C. Prim. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1388, 1389. 2 references.

Materials Engineering File Facts No. 218: Manufacturers Designations for Electronic Cores Produced from Metal Powders. *Materials & Methods*, Vol. 34, No. 5, November, 1951, p. 103, illus.

Barium Titanate Delay Lines. Leonard M. Orman and Leslie G. Callahan. *Electronics*, Vol. 24, No. 12, December, 1951, pp.

224, 228, 232, 236, 240, 244, illus. 4 references. Procedures and results of experiments in the development of barium titanate delay lines.

Dielectric Amplifier Fundamentals. A. M. Vincent. *Electronics*, Vol. 24, No. 12, December, 1951, pp. 84–88, illus.

Advantages and disadvantages of power amplification obtained through a variation of the dielectric of a capacitor in an a.c. power circuit by means of a control voltage applied independently to the capacitor; circuits; applications.

COMPUTERS

A Three Dimensional Electrical Potential Analyser. S. C. Redshaw. *British Journal of Applied Physics*, Vol. 2, No. 10, October, 1951, pp. 291–295, illus. 6 references.

Theory, construction, and circuit of an electric potential analyzer for solving the three-dimensional form of Laplace's equation, built for investigating the potential flow around airplane wings but applicable to any problem involving the Laplace equation. The analyzer uses a pure resistance network to solve the finite difference form of the potential equation; the potentiometer is capable of reading accurately to 1 millivolt.

Feedback Logical Computors. D. M. McCallum and J. B. Smith. *Electronic Engineering*, Vol. 23, No. 286, December, 1951, pp. 458–461, illus. 1 reference. Principles of operation of a feedback computer; types of problems which can be solved with feedback computers.

A Circuit for Generating Polynomials and Finding Their Zeros. F. W. Bubb, Jr. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 12, December, 1951, pp. 1556–1561, illus. 1 reference.

A Method for Obtaining the Products of Two Variables or Squares of Variables Electronically. Y. D. Altekar. *Journal of Scientific & Industrial Research*, Vol. 10B, No. 10, October, 1951, pp. 237–243, illus. 4 references.

Diagrams of circuits and components for an instrument that computes the products of two variables or squares of variables. The computer uses a Miller integrator modified for intermittent operation and a delay-multivibrator with linearity consistent with the stability.

Multi-Stable Magnetic Memory Techniques. John D. Goodell and Tenny Lode. *Radio & Television News*, Vol. 46, No. 6, December, 1951, *Radio-Electronic Engineering*, pp. 3–5, illus. Operation and application of bistable and multistable magnetic elements that are used for information storage in analog-to-digital computer translation.

High-Speed Relays in Electric Analogue Computers. R. R. Bennet and A. S. Fulton. *Electrical Engineering*, Vol. 70, No. 12, December, 1951, p. 1083, illus.

Circuits of a high-speed relay, driven by a high-gain d.c. amplifier, which is used to introduce comparison operations into an electric analog computer so that it can perform digital computations.

Superregulated Power Supplies. A. W. Vance and C. C. Shumard. *Electronics*, Vol. 24, No. 12, December, 1951, pp. 109–113, illus.

Five power supplies that give 0.001 per cent regulation as required for plate and bias voltages in the d.c. amplifiers that are used as integrators, differentiators, and multipliers in Project Typhoon's 4,000-tube analog-digital computer.

Simulation—Its Place in System Design. Harry H. Goode. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 12, December, 1951, pp. 1501–1506, illus.

The role of simulation in system design; steps in the simulation program; choice of computer; simulation of a human link in a system; evaluation of simulation with relation to cost, time, difficulty of operation, and accuracy.

CONSTRUCTION TECHNIQUES

Developments in the Design of Airborne Radio and Radar Equipment. *Electronic Engineering*, Vol. 23, No. 286, December, 1951, pp. 476–478, illus.

Problems encountered in keeping air-borne radio and radar equipment in operative condition; reasons for component failure; construction techniques, such as the hermetical sealing of units, to provide longer service life; operation of sealed equipment; miniaturization of components.

Down Goes Size of Airborne Radar. *Aviation Week*, Vol. 55, No. 23, December 3, 1951, pp. 57, 58, illus. Experimental construction of subminiature air-borne radar stations at Ryan Aeronautical Co.; heating, pressurization, and vibration problems.

ELECTRONIC TUBES

The Transit Time Effect in a Cylindrical Diode. Way Dong Woo. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1333–1339, illus. 6 references.

The impedance imposed on an alternating current by a space-charge limited cylindrical diode is expressed as a power series of the transit time angle that is equal to 2π times the ratio of the transit time to the period of the applied alternating current.

Letters to the Editor: Equivalent Temperature of an Electron Beam. M. E. Hines. **Discussion.** Philip Parzan. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1385, 1386, illus. 7 references. Analysis of the equivalent temperature that can be expected in the beam of a practical traveling wave tube; factors affecting beam temperature.

A Method of Measuring the Interface Resistance and Capacitance of Oxide Cathodes. C. C. Eaglesfield and P. E. Douglas. *British Journal of Applied Physics*, Vol. 2, No. 11, November, 1951, pp. 318–320, illus. 5 references.

Theory and operation of a measuring apparatus that makes use of the frequency-dependent feedback caused by the interface impedance. Another frequency-dependent network is inserted into the circuit, making the gain independent of the frequency. The interface components are then equal to the measuring components.

Cathode-Ray Tubes; A Review of Progress. L. F. Broadway. (*I.E.E., Paper No. 1184.*) *Institution of Electrical Engineers, Proceedings, Part I, General*, Vol. 98, No. 114, November, 1951, 316–320, illus. 22 references.

The Characteristics of Some Miniature High-Stability Glow-Discharge Voltage-Regulator Tubes. F. A. Benson. *Journal of Scientific Instruments*, Vol. 28, No. 11, November, 1951, pp. 339–341, illus. 7 references.

Results of tests to determine striking-voltage and running-voltage variations of three types of glow-discharge tubes; values for temperature coefficient of running voltage and for the magnitudes and duration of the initial drifts.

Amplitude Distribution Analyzer. R. E. Neinburg and T. F. Rogers. *Radio & Television News*, Vol. 46, No. 6, December, 1951, *Radio-Electronic Engineering*, pp. 8–10, illus. 7 references. The RCA type STE-A barrier-grid storage tube; its use in an instrument that realizes statistical distributions.

Space-Charge and Ion-Trapping Effects in Tetrodes. Karl G. Hernqvist. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 12, December, 1951, pp. 1541–1547, illus. 10 references.

Space-Charge Effects in Reflex Klystrons. M. Chodorow and V. B. Westburg. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 12, December, 1951, pp. 1548–1555, illus. 11 references.

MEASUREMENTS & TESTING

Accurate Frequency Calibration Method. *Electronics*, Vol. 24 No. 12, December, 1951, pp. 260, 264, 266, illus.

A method that produces a signal that is exactly equal to the standard frequency whenever the signal to be calibrated is adjusted to any detectable harmonic of the standard frequency.

The Design and Use of an Admittance Bridge for Piezoelectric Crystals. J. F. W. Bell. *British Journal of Applied Physics*, Vol. 2, No. 11, November, 1951, pp. 324–327, illus. 3 references. Theory and operation of a radio frequency bridge (250 to 500 kc. per sec.) for measuring the resistance and Q-factor of piezoelectric crystals.

POWER SUPPLIES

Superregulated Power Supplies. A. W. Vance and C. C. Shumard. *Electronics*, Vol. 24, No. 12, December, 1951, pp. 109–113, illus.

Five power supplies that give 0.001 per cent regulation as required for plate and bias voltages in the d.c. amplifiers that are used as integrators, differentiators, and multipliers in Project Typhoon's 4,000-tube analog-digital computer.

A Stabilized A.C. Supply for Lamps and Valve Heaters. J. C. S. Richards. *Journal of Scientific Instruments*, Vol. 28, No. 11, November, 1951, pp. 333–335, illus. 3 references.

Design and operation of a system that uses a saturated diode as a reference element and a saturable choke as control element,

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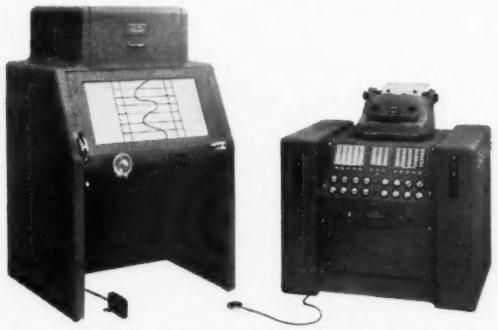

1. The Universal Telereader measures film and paper records of any width, ranging from 16 and 35 mm film to 12" oscillograph records

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Types of records—handles translucent or opaque records; continuous roll records up to 100 feet in length or single sheet records up to 12" in width

Speed—up to 50 measurements per minute

Optical system—three interchangeable lenses give magnification of 2X, 4X and 14X

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2. The Telecordex electronically counts, stores and records the measurements of the Telereader in decimal form, prints them on the typewriter for preliminary analysis.

It also can transmit the data to an IBM Summary Punch for simultaneous card punching.

VITAL DATA

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Typing rate—50 operations per line; 600 operations per minute

Counting rate—up to 15,000 counts per second (5,000 during read-out)

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Servomechanism behavior data

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Strip Charts

Multiple Manometer Data

Mass spectrometer data

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RADAR

Information Theory and the Design of Radar Receivers. Philip M. Woodward. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 12, December, 1951, pp. 1521–1524, illus. 6 references. Outline of a mathematical method by which a theoretically ideal radar receiver may be specified, based on the principle of inverse probability and the information function.

Developments in the Design of Airborne Radio and Radar Equipment. *Electronic Engineering*, Vol. 23, No. 286, December, 1951, pp. 476–478, illus.

Problems encountered in keeping air-borne radio and radar equipment in operative condition; reasons for component failure; construction techniques, such as the hermetical sealing of units, to provide longer service life; operation of sealed equipment; miniaturization of components.

A Model Technique for the Measurement of the Radar Characteristics of Targets. David L. Ringwalt. *U.S., Naval Research Laboratory, Washington, Report No. 3800*, June 29, 1951. 16 pp., illus. 4 references. Operation of a system for the dynamic measurement of the radar area of target models; calibration; details of components and target support.

SATURABLE REACTORS

A Static Magnetic Exciter for Synchronous Alternators. H. F. Storm. *Electrical Engineering*, Vol. 70, No. 12, December, 1951, pp. 1084–1088, illus. 7 references.

Equations and design for a basic magnetic exciter circuit that permits maximum self-regulation of the terminal voltage of the alternator of a voltage regulator. The remaining deviations of output voltage provide a correction signal to the exciter that keeps steady-state voltage within ±0.6 per cent.

TELEMETRY

Upper Atmosphere Research Report No. X: The Matrix Telemetering System. J. T. Mengel, N. R. Best, D. G. Mazur, and K. M. Uglow. *U.S., Naval Research Laboratory, Washington, Report No. 3535*, September 19, 1951. 87 pp., illus., folding charts. 6 references.

A 30-channel matrix telemetering system of medium-high repetition rate for use in high-altitude rockets which operates at a frequency of 1,025 megacycles per sec. Pulse-time modulation conveys the input information; data channels are read successively. The matrix system uses pulse-position modulation and is synchronized by a coded triple-pulse that precedes each set of data pulses. Films record the signals from six cathode-ray tubes on which the 30 data channels can be applied in any combination. Components of the system are explained; diagrams show the principal circuits.

TRANSMISSION LINES

Slotted Line Techniques. E. G. Hamer. *Electronic Engineering*, Vol. 23, No. 286, December, 1951, pp. 466–470, illus. 3 references.

Investigation of the characteristics of transmission lines by inserting a slotted-line section into the circuit; characteristics of the slotted line to minimize the introduction of errors; calibration; measurement of impedance and other characteristics of the transmission line.

The Susceptance of a Thin Iris in Circular Wave Guide with TM_{01} Mode Incident. Kenneth L. Dunning and Rufus G. Fellers. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1316–1320, illus. 5 references.

Analysis, using Schwinger's integral equation method, of the susceptance of a thin circular iris in a circular cylindrical wave guide, in terms of transmission line concepts and equivalent lumped-constant circuits.

Square Wave Guide Attenuation. *Radio & Television News*, Vol. 46, No. 6, December, 1951, *Radio-Electronic Engineering*, p. 32, illus. A nomograph for determining the attenuation of the $TM_{1,1}$ mode in a square air-dielectric wave guide.

WAVE PROPAGATION

The Source of Long-Distance Backscatter. William G. Abel and Leonard C. Edwards. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 12, December, 1951, pp. 1538–1541, illus. 4 references. Development of a method for determining the source of long-distance backscatter of electromagnetic radiation; equipment; data analysis.

Direction Finder and Flow Meter for Centimeter Waves. Kiyoshi Morita. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 12, December, 1951, pp.1529–1534, illus. Development of an indicator that shows directly the net energy flow, based on a single measurement.

An Analysis of the Effect of the Discontinuity in a Bifurcated Circular Guide upon Plane Longitudinal Waves. Louis L. Bailin. *U.S., National Bureau of Standards, Journal of Research*, Vol. 47, No. 4, October, 1951, pp. 315–335, illus. 19 references. (Also available as *Research Paper No. 2258*. Superintendent of Documents, Washington. $0.15.)

Solution, by restricting incident plane waves to the lowest propagating mode, for the scattering of waves by a semi-infinite circular tube with a diameter inserted axially.

The Influence of Magnetic Fields upon the Propagation of Electromagnetic Waves in Artificial Dielectrics. E. R. Wicher. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1327–1329. 7 references.

Letters to the Editor: A Note on "Attenuation of Radio Signals Caused by Scattering" by A. H. LaGrone, W. H. Benson, Jr., and A. W. Straiton. J. B. Smyth and C. P. Hubbard. **Reply.** A. H. LaGrone. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1386, 1387.

Equipment

HYDRAULIC & PNEUMATIC (20)

Air in Hydraulic Transmission Systems. D. Rendel and G. R. Allen. *Aircraft Engineering*, Vol. 23, No. 273, November, 1951, pp. 337, 338, illus. The effect, on the reversibility of a hydraulic mechanism, of the variations in the bulk modulus of the fluid.

Flight Operating Problems (31)

HIGH-SPEED FLIGHT

Problems of High Speed Flying. I—Physical Analysis and Aerodynamics. Ved. Kumar. *Indian Air Force Quarterly*, Vol. 1, No. 4, October, 1951, pp. 66–77, illus. 7 references.

ICE PREVENTION & REMOVAL

A Summary of Meteorological Conditions Associated with Aircraft Icing and a Proposed Method of Selecting Design Criterions for Ice-Protection Equipment. Paul T. Hacker and Robert G. Dorsch. *U.S., N.A.C.A., Technical Note No. 2569*, November, 1951. 35 pp., illus. 11 references.

Heat on CV De-Ices the Corsair. *Aviation Week*, Vol. 55, No. 23, December 3, 1951, pp. 48, 50, 53, 54, illus. Installation of rubber deicing boots on wing and tail surfaces of Chance Vought's winterized Corsair night-fighter aircraft.

REFUELING IN FLIGHT

Airborne Refueling Bases. Norman MacMillan. *Interavia*, Vol. 6, No. 11, November, 1951, pp. 603–606, illus. Flight refueling of jet fighters using the "probe-and-drogue" and "flying boom" techniques; U.S. and British experience with flight refueling.

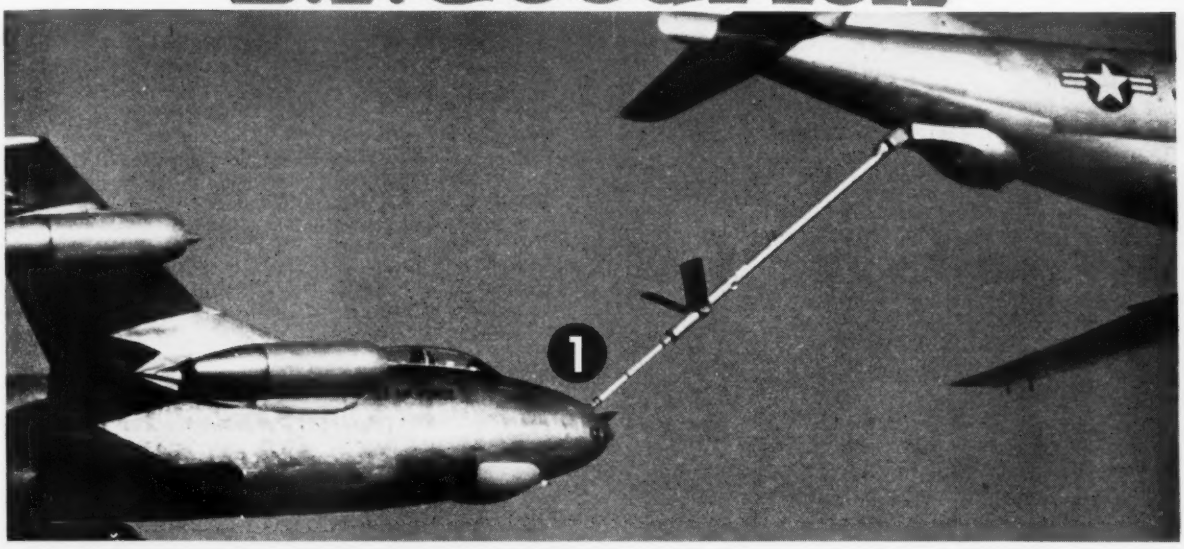
Fox-Able-Four. Norman MacMillan. *Flight*, Vol. 60, No. 2237, December 7, 1951, pp. 712, 713, illus. Problems and techniques in the flight refueling of two Republic F-84E Thunderjets during an Atlantic nonstop flight.

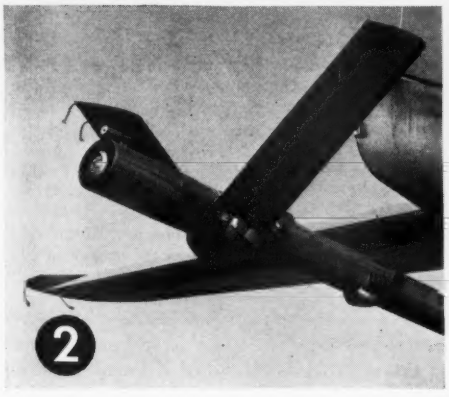
Hydraulics and the Airship. Beverly A. Dodge. *Hydraulic Engineer*, Vol. 1, No. 4, October-November, 1951, p. 3, illus. Development of an hydraulic in-flight refueling system for airships by Flight Refueling, Inc.

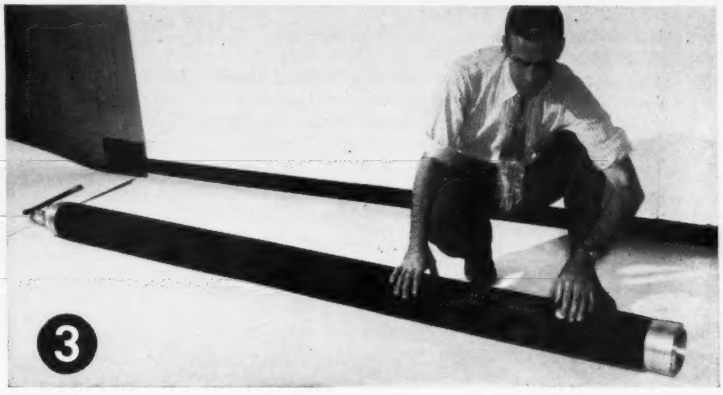
Fuels & Lubricants (12)

Detonation. G. Broersma. *Indonesia, Journal for Scientific Research, O.S.R. News*, Vol. 3, No. 8, August, 1951, pp. 172–175, illus. 9 references. Analysis of the physical and chemical mechanisms of knock.

B.F.Goodrich







How rubber helps a bomber stretch its range

B-47 BOMBERS are refueled in flight by the Flying Boom—new telescoping pipe for in-flight refueling, developed by Boeing. Its vee-shaped ruddevators guide it into a fueling receptacle—special opening in the receiver ship. To make the boom practical, Boeing engineers faced three problems which they brought to B. F. Goodrich:

1. Ice forming in flight might choke up the receptacle, make it impossible for the boom to enter. B. F. Goodrich engineers suggested electric rubber—thin, tough rubber heated by a core of electric resistance wires. To fit snugly over bulges and around curves, BFG built the rubber in twelve molded sections. It fitted skin-tight over the contours of the receptacle, kept it ice-free.

2. Control surfaces of the ruddevators had to be kept free of ice. B. F. Goodrich again recommended heated rubber. Bonded to the leading edges of the ruddevators, pads of electric rubber supplied spot anti-icing heat, permitted accurate control of the Flying Boom.

3. Sudden shutting off of fuel at the nozzle of the boom would deliver a kick which might damage the fuel pipe. Boeing had an idea for a "surge boot"—one rubber sleeve inside another with an air chamber between, which would act like a shock absorber to cushion the jolt. BFG came up with a boot of man-made rubber on nylon fabric. It was light in weight, didn't stiffen from cold, had the strength needed to take the kick of the surging fuel. It prevented damaging jolts to the pipe.

These are typical of the aviation developments that have come from B. F. Goodrich, leader in rubber research and engineering. BFG products for aviation include tires, wheels and brakes; heated rubber; De-Icers; Avtrim; inflatable seals; Pressure Sealing Zippers; fuel cells; Plastilock adhesives; Rivnuts; accessories. *The B. F. Goodrich Company, Aeronautical Division, Akron, O.*

B.F.Goodrich
FIRST IN RUBBER

Infrared Spectra of 59 Dicyclic Hydrocarbons. K. T. Serijan, I. A. Goodman, and W. J. Yankauskas. *U.S., N.A.C.A., Technical Note No. 2557*, November, 1951. 37 pp., illus. 5 references.

Diagrams of the infrared spectra and tables of the physical properties of 59 dicyclic hydrocarbons consisting of some diphenylalkanes, dicyclohexylalkanes, alkylbiphenyls, and alkylbicyclohexyls ranging from C_{12} to C_{18}.

Reduction of the Vanadium Content of Residual Petroleum Fuels by Solvent Precipitation. W. Sacks. *Canadian Journal of Technology*, Vol. 29, No. 11, November, 1951, pp. 492–495. 13 references.

Investigation of the removal of vanadium from residual petroleum fuels that are used in gas turbine engines in an attempt to lessen the corrosive effect of these fuels on the alloy steels at high temperatures; both polar and hydrocarbon solvents were tested.

Jet Fuels—the Airline Viewpoint. J. T. Hendren and J. G. Borger. *Esso Air World*, Vol. 4, No. 2, September-October, 1951, pp. 32–36, illus. Types of jet fuels required by air lines; technical and economic considerations; ground-handling problems.

The Nature of the Static and Kinetic Coefficients of Friction. Ernest Rabinowicz. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1373–1379, illus. 11 references.

Transition between static and kinetic friction conditions; development of a method for determining the distance over which the static coefficient of friction operates; action of boundary lubricants.

Gliders (35)

Low-Speed Wind-Tunnel Tests on the Baynes Carrier Wing; a Tailless Glider. J. Trounce. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2487*, 1951 (November, 1947). 41 pp., illus. 7 references. British Information Services, New York. $2.45. Longitudinal and lateral stability tests on the Baynes Carrier Wing, both in its original design as a tailless tank-carrying glider and with the tank replaced by a fuselage.

Guided Missiles (1)

What We Have Learned from V-2 Firings. *Aviation Week*, Vol. 55, No. 22, November 26, 1951, pp. 23, 24, 27, 29, 30, 35, illus. Results of Project Hermes' firing of the German V-2 rocket in the U.S.; firing program; analysis of performance data and firing techniques; causes of misfiring and other errors.

Upper Atmosphere Research Report No. X: The Matrix Telemetering System. J. T. Mengel, N. R. Best, D. G. Mazur, and K. M. Uglow. *U.S., Naval Research Laboratory, Washington, Report No. 3535*, September 19, 1951. 87 pp., illus., folding charts. 6 references. A 30-channel matrix telemetering system of medium-high repetition rate for use in high-altitude rockets.

Instruments (9)

Discrete Energy Levels of a Nonlinear Oscillator. James H. Moran. *Journal of Applied Physics*, Vol. 22, No. 11, November, 1951, pp. 1355–1358, illus. 4 references.

Mechanics of nonlinear systems; attainment of discrete energy levels rather than a continuous energy spectrum; the nonlinear quantum effect and its similarity to the harmonic quantum oscillator.

An Amplidyne Phase Shift Oscillator. John C. West. *Journal of Scientific Instruments*, Vol. 28, No. 11, November, 1951, pp. 336–338, illus. 8 references.

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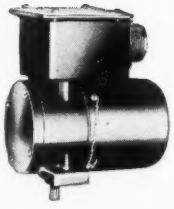
versatility in actuator design



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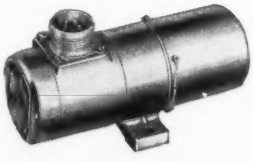

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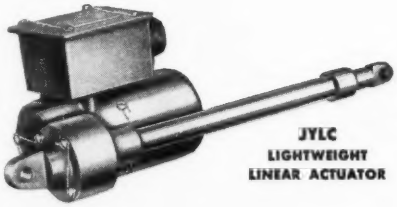

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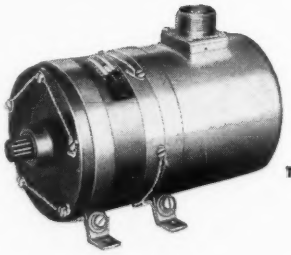

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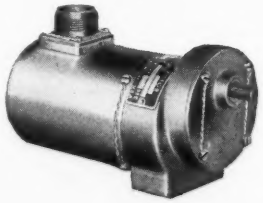

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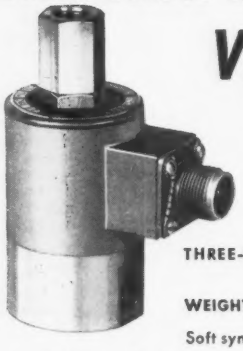

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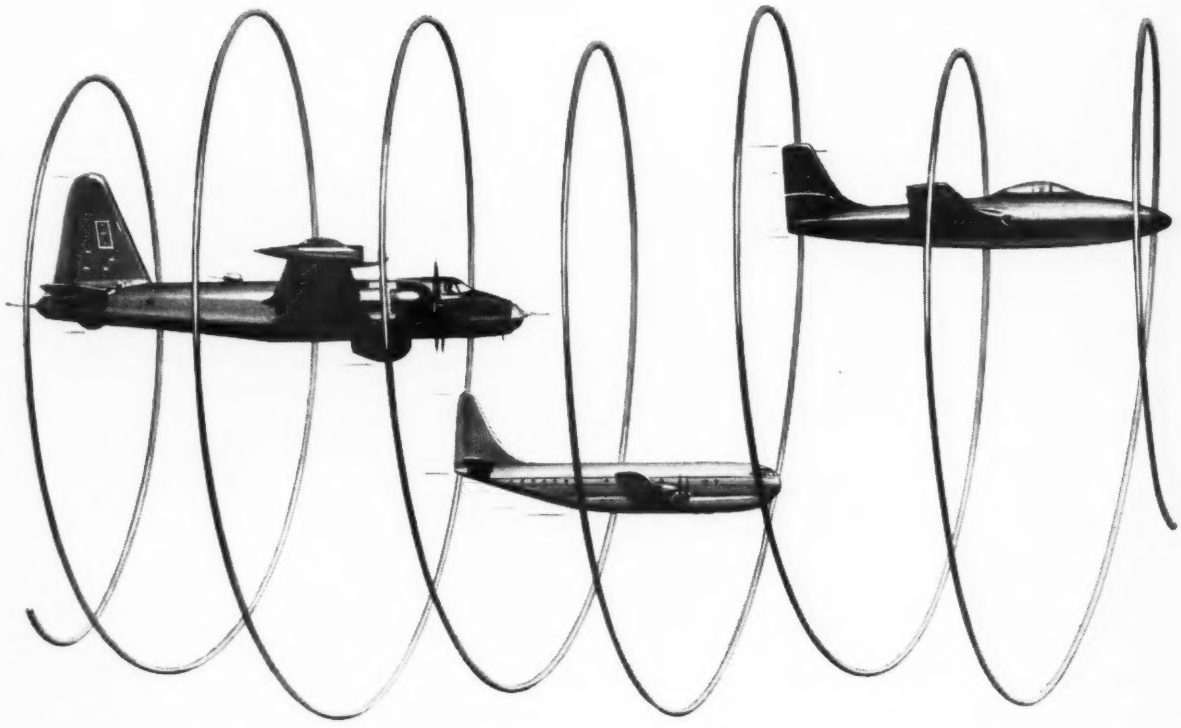

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Ionospheric Cross-Modulation. I. J. Shaw. *Wireless Engineer*, Vol. 28, No. 338, November, 1951, pp. 335–342, illus. Sur-

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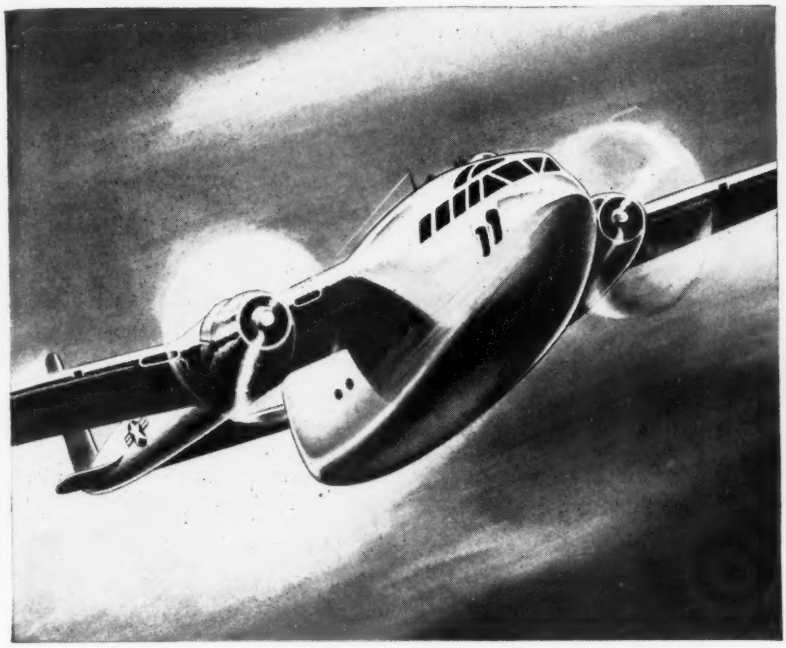

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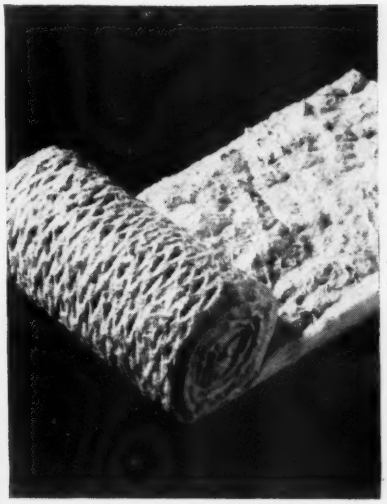

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vey of recent experimental and theoretical work done in England on ionospheric cross-modulation.

Military Aviation (24)

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Navigation (29)

Aircraft Navigational Aids. *The Engineer*, Vol. 192, No. 5001, November 30, 1951, pp. 702, 703, illus.

Design, operation, and performance of the Marconi A.D. V.H.F. D/F equipment that allows ground operators to read off bearings instantaneously to the pilot of a high-speed aircraft that is approaching the airport; experience using this equipment in the traffic control of jet aircraft at the airport of the de Havilland Aircraft Co., Ltd., Hatfield; Mullar Electronic "Telescribe" equipment for the exchange of air traffic control information between ground stations; service experience with the Decca Flight Log.

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The Design of an Omni-Directional Aerial System for the Frequency Range 225–400 Mc/s. F. A. Kitchen. (*I.E.E., Radio Section, Paper No. 1180.*) *Institution of Electrical Engineers, Proceedings, Part III, Radio and Communication Engineering*, Vol. 98, No. 56, November, 1951, pp. 409–415, illus. 12 references.

"Mercator" Air Navigation Computor. William D. Forssman. *Interavia*, Vol. 6, No. 11, November, 1951, p. 630, illus.

Design and uses of the Mercator B-3 Computer. Basically similar to the Dalton Dead Reckoning Computer, the Mercator provides additional scales for computing flight data, as well as I.C.A.O. standard conversion tables.

Ordnance & Armament (22)

Reduction of Gun-Gas Explosion Hazard in Combat Aircraft. J. J. Horan, J. R. Onderdonk, and E. Witkin. *Aeronautical Engineering Review*, Vol. 11, No. 3, March, 1952, pp. 37–43, illus.

F-89D Scorpion Carries Wingtip Stings. *Aviation Week*, Vol. 55, No. 23, December 3, 1951, p. 15, illus. The Northrop F-89D scorpion has wingtip-mounted containers for rockets and electronic equipment that aims and fires them automatically.

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Review of the methods of parachute design developed in Great Britain during World War II; effects of design parameters on parachute performance characteristics; evaluation of parachute types; criteria for deciding which type of parachute is best suited to a specific purpose.

Photography (26)

A New Method for the Photographic Study of Fast Transient Phenomena. J. S. Courtney-Pratt. *Research*, Vol. 2, No. 6, June, 1949, pp. 287–293, illus. 40 references.

A method of photographing transient phenomena occurring in 10^{-7} to 10^{-8} sec. The method uses an image converter combined with an electronic time-base deflection system. Writing speeds up to 10^8 meters per sec. can be obtained. Either single exposures of duration as short as 10^{-7} sec. or a succession of exposures at intervals of about 1 μsec. can be obtained.

They Shoot the U.S.A. John G. Hubbell. *Honeywell Flight Lines*, Vol. 2, No. 4, pp. 1–5, illus.

Development of a high-altitude (36,000-ft.) aerial mapping technique by the Mark Hurd Mapping Co., Minneapolis; cameras used and their installation; hazards to personnel and equipment.

Power Plants

ATOMIC

Nuclear-Energy Propulsion; An Examination of Its Possibilities for Aircraft and Rockets. *Flight*, Vol. 60, No. 2235, Friday, November 23, 1951, pp. 656–658.

On a Theory of Polar Forces As a Principle for Application of Atomic Energy to Rocket Propulsion. III. Hans J. Kaeppeler. *Rocketscience*, Vol. 5, No. 4, December, 1951, pp. 83–87, illus. 1 reference. Mathematical analysis of the propagation processes in the nondegenerative zone, assuming a spherically-formed source.

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Lubrication—Bearing Problems in Aircraft Gas Turbines. E. M. Phillips. *Mechanical Engineering*, Vol. 73, No. 12, December, 1951, pp. 983–988, illus. 4 references.

Turbine Starter; Machining the Rotax Two-Shot Breech Casting. *Aircraft Production*, Vol. 13, No. 158, December, 1951, pp. 368–372, illus.

RECIPROCATING (6)

Cams and Followers for High-Speed Internal Combustion Engines. I. II. E. Fuhrmann. (*Maschinenbau und Wärmewirtschaft*, Vol. 6, No. 8, August, 1951, pp. 126–134.) *Engineers' Digest*, Vol. 12, Nos. 10, 11, October, November, 1951, pp. 340–342, 348; 368–370, illus. 14 references.

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A diverter-segregator consisting of a finned tank, with inlet and outlet valves, which fits inside the fuel tank of a B-36. Developed by United Aircraft Products, Inc., the system decongeals and deaerates engine oil in subzero weather.

ROCKET (4)

Time Dependence of Pressure in Restricted Burning Solid Propellant Rocket Motors. Melvin G. Whybra. *Rocketscience*, Vol. 5, No. 4, December, 1951, pp. 74–82, illus. 3 references.

Mathematical analysis of the mechanism of the pressure vibration in a restricted burning rocket motor and of its dependence upon the time elapsed since igniton; physical significance of the analysis. Results are presented as pressure-time and thrust-time curves.

Rockets for Aircraft Propulsion. S. Allen. *The Aeroplane*, Vol. 81, No. 2107, December 7, 1951, pp. 726, 727, illus. Propellant selection problems; optimum propellant combination; fuel system and refueling techniques of the Armstrong-Siddeley Snarler liquid-fuel rocket motor.

Production (36)

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Metal Stitching Speeds Assembly, Reduces Cost. II. Arthur G. Denne. *Tool Engineer*, Vol. 27, No. 6, December, 1951, pp. 50–52, illus.

Design for Redux. H. Giddings. *Aircraft Production*, Vol. 13, No. 158, December, 1951, pp. 387–391, illus. 2 references. Design research and practical application of Redux-bonding procedures to four types of Bristol aircraft; test results.

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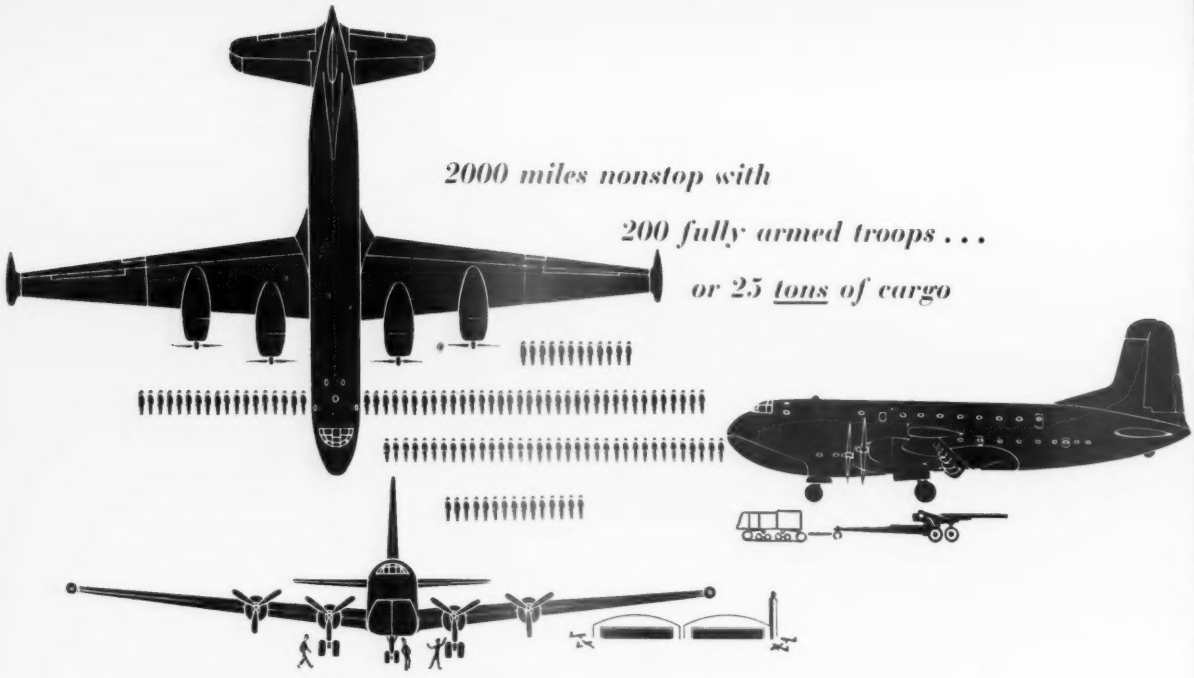

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Stretch-Forming. G. W. Weeks. *Aircraft Production*, Vol. 13, No. 158, December, 1951, pp. 393–395, illus. A subcritical annealing treatment to prevent the "orange-peel" effect on the surface of aluminum alloy sheets during stretch-forming.

Planning the Air Force Heavy Press Program. I—Larger Forgings Aid Aircraft Production. K. B. Wolfe. *Steel Processing*, Vol. 37, No. 11, November, 1951, pp. 551–554, illus.

Heat Treatment of Engineering Materials. I. G. Meikle. *The Technical Instructor*, Vol. 6, No. 10, October, 1951, pp. 3–9, illus. Analysis of the chemical and structural properties induced in metals by various methods of heat-treating

Abrasive Liquid Blasting. N. J. Gorayetski. (*Stanki i Instrument*, Vol. 22, No. 7, 1951, pp. 27–31.) *Engineers' Digest*, Vol. 12, No. 11, November, 1951, pp. 365–368, illus.

Test results on metal removal by blasting with an abrasive liquid; design and operation of equipment, built on the basis of these tests, for directing the abrasive jet onto the treated surface, using compressed air; effects of individual factors on the abrasive liquid blasting process.

Drilling and Deburring; Ryan Equipment for Gas-Turbine Exhaust Cones. *Aircraft Production*, Vol. 13, No. 158, December, 1951, p. 381, illus.

Superfine Grinding. F. Cattin. *Aircraft Production*, Vol. 13, No. 158, December, 1951 pp. 384–386, illus. A method developed by the Société Genevoise d'Instruments de Physique for obtaining a mirror finish on the races of tapered-roller bearings.

Turbine Starter. *Aircraft Production*, Vol. 13, No. 158, December, 1951, pp. 368–372, illus. Design, production, and machining procedure for the breech casting of the Rotax cartridge-type gas-turbine starter.

Machining Airscrew Hubs; Automatic Chucking-Lathe Conversion for Preliminary Boring Operations on Blade-Root Housings. *Aircraft Production*, Vol. 13, No. 158, December, 1951, pp. 379–381, illus.

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Machinery Vibration Elimination. Lyne S. Metcalfe. *Aero Digest*, Vol. 63, No. 6, December, 1951, pp. 94–97, illus. Losses in efficiency and production and increased operating costs due to machinery vibration; corrective techniques and materials used.

P & W Salvages Gold Mine. *Aero Digest*, Vol. 63, No. 6, December, 1951, pp. 105–107. Pratt & Whitney's program for collecting and processing scrap material.

NAA Reveals Improved Test Methods. Irving Stone. *Aviation Week*, Vol. 55, No. 24, December 10, 1951, pp. 38–40, 46, illus. Production-testing and inspection techniques and equipment at North American Aviation, Inc.

A Brief Survey of the Practicability of MIL-STD-105A Within the Aircraft and Associated Industries. Fay Carlson. *Industrial Quality Control*, Vol. 8, No. 3, November, 1951, pp. 28, 29.

New Tools for New Methods. *Aircraft*, Vol. 13, No. 11, November, 1951, pp. 11, 13, 14, illus. Tools developed in U.S. and Canadian aircraft plants for the production of jet engines, fuselages, and wings for fighter aircraft.

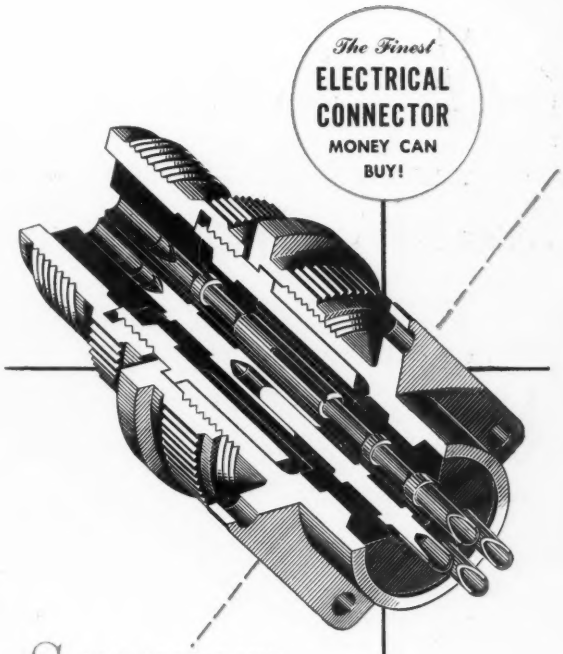
Propellers (11)

Flying the "Flex-O-Prop" Aeronca. John Fricker. *The Aeroplane*, Vol. 81, No. 2106, November 30, 1951, pp. 712–713, illus. Design and performance of an Aeronca Type 7AC Champion equipped with the Munk variable-pitch, one-piece propeller.

Strain Gauge Investigation of Propeller Flutter. L. H. G. Sterne, H. G. Ewing, and J. Kettlewell. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2472*, 1951 (January, 1947). 7 pp., illus. 2 references. British Information Services, New York. $0.50.

Rotating Wing Aircraft (34)

An Investigation in Flight of the Induced Velocity Distribution Under a Helicopter Rotor When Hovering. P. Brotherhood. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2521*, 1951 (June, 1947). 16 pp., illus. 3 references. British Information Services, New York. $1.15.



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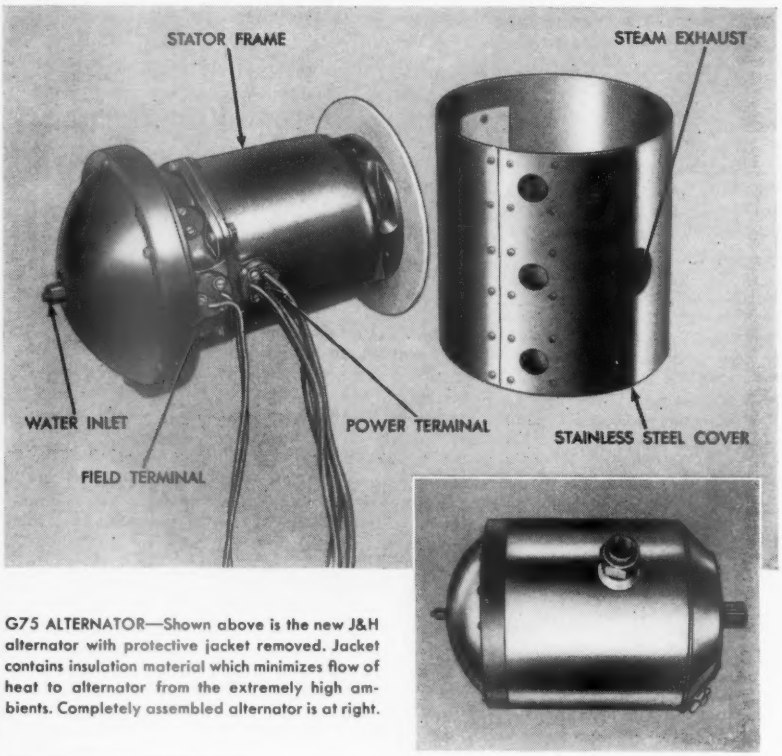
Jack & Heintz engineers, with this in mind, have been working for some time on the development of power units offering environment-free operation which, at the same time, imposes a minimum over-all penalty on the airplane.

Several units of this kind have been developed by J&H. One of these —the G75 Alternator, utilizes liquid vaporization cooling action. It is the first successful environment-free, water-vaporization-cooled alternator in the industry. Due to an efficiency of about 93 per cent, only 3½ lb/hr of water are required at rated load. Operation is limited to a cycle, dependent on the capacity of accompanying coolant reservoir.



G75 ALTERNATOR—Shown above is the new J&H alternator with protective jacket removed. Jacket contains insulation material which minimizes flow of heat to alternator from the extremely high ambients. Completely assembled alternator is at right.

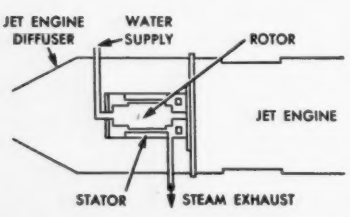
In operation, coolant from the reservoir is injected into the alternator's hollow shaft under pressure. As the coolant is distributed throughout the machine by centrifugal force imparted from rotating members, the latent heat of vaporization extracts machine heat losses. Resultant steam is permitted to escape through an exhaust port. Water inlet flow is regulated automatically by a special J&H valve which is controlled by a temperature-sensing element in the alternator.

Conventional alternators, inherently non-isolated from adverse ambient conditions, must be correspondingly derated for the 35,000 to 60,000 feet, and above, altitude range. The G75, a 3-phase, 400-cycle, 12,000 rpm unit, rated at 12 kva, can deliver 16 kva and maintain satisfactory cooling while operating in extreme conditions of temperature and altitude.

Field power for the machine is taken from the output leads through slip rings and brushes, passed through the rectifier bank and magnetic amplifier of the specially designed GR75 Exciter-Voltage Regulator, and then to the field.

Brush wear problems are minimized in the alternator since the steam atmosphere acts as a lubricant between the brushes and slip rings, prolonging brush life.

The G75 Alternator is rated at a power factor of 80 per cent, weighs 39 lbs., is 12⅝ in. long and 9 in. in diameter. It is an engine-mounted unit with a 6 in. flange diameter and a 5 in. bolt circle diameter, adaptable to an AND 20002 mounting pad.



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NEW ALTERNATOR OFFERS ADVANTAGES TO JET AIRCRAFT AND GUIDED MISSILE DESIGNERS

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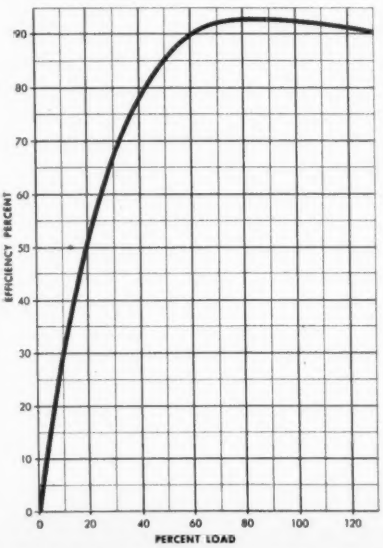
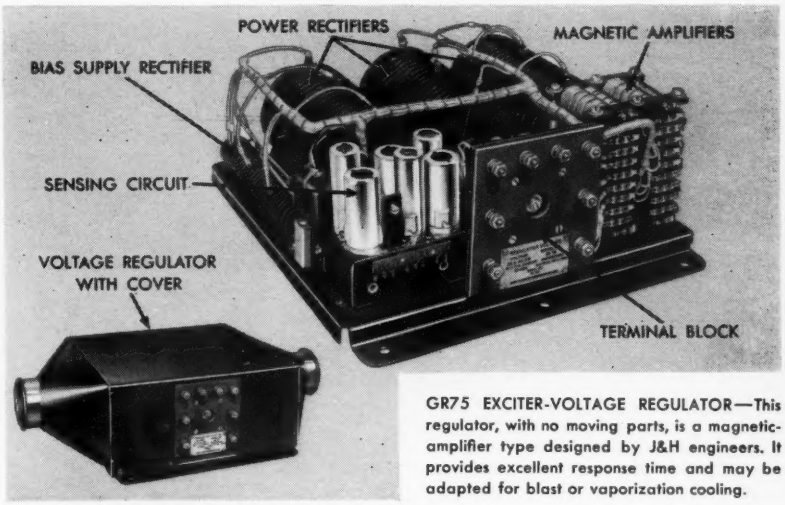
2. Heat transfer coefficients for boiling water are 20 to 200 times that for air.
3. High heats of vaporization tend to keep weight of coolant required at reasonably low value (3.4 lb/hr/kw of losses).
4. For short duration or expendable flights, no control is required beyond a simple orifice set to meet full load cooling requirements. Weight of additional coolant used would, in most cases, be less than the weight of a more accurate control.
5. In certain installations, water could be kept from freezing by storing in a separate container such as the oil reservoir, or low freezing-point evaporants may be used.



Graph shows efficiency versus load for the G75 Alternator at unity power factor.



GR75 EXCITER-VOLTAGE REGULATOR—This regulator, with no moving parts, is a magnetic-amplifier type designed by J&H engineers. It provides excellent response time and may be adapted for blast or vaporization cooling.

Chief Engineer's Corner

While we feel that the development of the vaporization-cooled alternator is a definite step toward a solution to the problem of cooling generators on high-speed, high-altitude airplanes, we also recognize that vaporization cooling is not a panacea. Each installation requires careful study to determine the best methods of cooling.

Our engineers have completed the development of two additional types of machines. One of these is a high-efficiency air-cooled, d-c machine in which various new, high-temperature materials have been applied to raise the allowable operating temperature.

The second, also a d-c machine, has been designed for liquid cooling. In this unit, the coolant is passed through the armature and brush holders, and around the field windings.

Since high-speed, high-altitude aircraft are not required to remain aloft as long as in the past, flight duration is a major consideration in determining the best method of cooling electrical equipment. In certain applications, over-all system weight and size may be less if equipment is designed to store its generated heat rather than to dissipate it.

The experience we have gained in the development of these machines during the past few years has proved invaluable to us.

The benefits of this experience are available to your engineers. Write for J&H Technical Bulletin No. 1200, Jack & Heintz, Inc., Dept. 403, Cleveland 1, Ohio.

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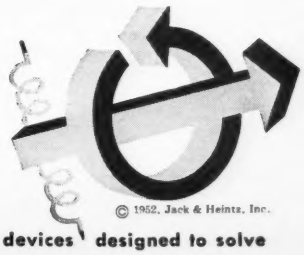

means electrical, hydraulic or mechanical devices designed to solve unusual problems of developing power, controlling it, or using it.

Flight tests on a Sikorsky R-4B Helicopter to determine the velocity distribution induced by the rotor in hovering flight; instrumentation and test techniques; smoke visualization of the streamlines; comparison with the velocity distribution obtained by propeller strip theory calculations.

Hiller Copter Has 'New Look.' *Aviation Week*, Vol. 55, No. 23, December 3, 1951, pp. 41, 42, illus. Major engineering changes introduced into the H-23B model of the Hiller 360 commercial helicopter as a result of Korean service experience.

The Giant Helicopter. O. L. L. Fitzwilliams. *The Aeroplane*, Vol. 81, No. 2106, November 30, 1951, pp. 692–695, illus. *Flight*, Vol. 15, Nos. 2236, 2237, November 30, December 7, 1951, pp. 672–674; 728–731, illus. (Based on a paper given before the Helicopter Association of Great Britain, November 23, 1951.) Design analysis developed at Westland Aircraft, Ltd., for jet-driven helicopters having a gross weight of 60,000 lbs. and capable of lifting 45 tons.

Design Features of the Seibel (S-4) Helicopter. G. F. Champlin. *American Helicopter*, Vol. 24, No. 11, October, 1951, pp. 6–8, 12, illus.

Sciences, General (33)

MATHEMATICS

High-Speed Relays in Electric Analogue Computers. R. R. Bennett and A. S. Fulton. *Electrical Engineering*, Vol. 70, No. 12, December, 1951, p. 1083, illus.

A high-speed relay, driven by a high-gain d.c. amplifier, is used to introduce comparison operations into an electric analog computer so that it can perform digital computations.

A Method for Obtaining the Products of Two Variables or Squares of Variables Electronically. Y. D. Altekar. *Journal of Scientific & Industrial Research*, Vol. 10B, No. 10, October, 1951, pp. 237–243, illus. 4 references.

An instrument that uses electronic circuits that conform to the relation $v^2 = 2\int v \cdot dv$ to obtain the products of functions and the sum of the squares of deviations of any time-varying physical quantity from its slowly varying mean value.

Altigram Solves Research Problems. Cyril G. Veinott. *Aero Digest*, Vol. 63, No. 6, December, 1951, pp. 54, 56, 58.

An altigram with scales giving temperature for °C. and °F., pressure altitudes and absolute pressure, and density altitude and specific weight of the air. Single scales may be used for simple conversions or the three scales may be used as a nomogram.

Airspeed Computor. Ralph Waechter. *Aero Digest*, Vol. 63, No. 6, December, 1951, pp. 84, 86, 88, 90, 92, illus.

Operation of a slide rule, the scales of which must be constructed separately for any given type of aircraft, with accuracy of ±.002 Mach Number to ±1° temperature and ±1 knot to true air speed. True air speed is determined in four operations during which the true Mach Number and ambient temperature are also determined.

Numerical Integration of Stiff Equations. C. F. Curtiss and J. O. Hirschfelder. *Wisconsin, University, Naval Research Laboratory, Department of Chemistry, Report No. CM-694*, November 23, 1951. 7 pp.

Presentation of a method of numerical integration for a class of first-order differential equations that have stiff coupling between the solution and a driving function; properties of stiff equations.

Separation of Close Eigenvalues of a Real Symmetric Matrix. J. B. Rosser, C. Lanczos, M. R. Hestenes, and W. Karush. *U.S., National Bureau of Standards, Journal of Research*, Vol. 47, No. 4, October, 1951, pp. 291–297. 4 references. (Also available as *Research Paper No. 2256*. Superintendent of Documents, Washington. $0.10.)

Topological Aspect of Forced Oscillations. M. L. Cartwright. *Research*, Vol. 1, No. 13, October, 1948, pp. 601–606, illus. 13 references. Nonlinear equations for engineering problems concerned with forced oscillations.

Structures (7)

On Symmetrical Strain in Solids of Revolution in Spherical Coordinates. Chih-Bing Ling and Kuo-Liang Yang. *Journal of Applied Mechanics*, Vol. 18, No. 4, December, 1951, pp. 367–370, illus. 7 references.

Presentation of expressions for the displacements and stresses in the spherical coordinates, in terms of a stress function, for a solid of revolution in the state of symmetric strain. The stress function is constructed in terms of Legendre polynomials.

Torsion and Bending of Prismatic Rods of Hollow Rectangular Section. B. L. Abramyan. (*Prikladnaia Matematika i Mekhanika*, Vol. 14, No. 3, 1950, pp. 265–276.) *U.S., N.A.C.A., Technical Memorandum No. 1319*, November, 1951. 24 pp., illus. 7 references.

Development of formulas for determining the stiffness in torsion and bending of prismatic rods of hollow rectangular cross-sections in terms of the geometric parameters of the section; limits of the applicability of the Bredt formula.

Photo-Elastic Examination of a Cylindrical Strut Intended for Recording Compressive Loads. W. A. P. Fisher. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2532*, 1951 (February, 1947). 4 pp., illus. British Information Services, New York. $0.35. Photoelastic analysis of the stresses in a cylindrical steel strut under compressive bending to determine what portion of the strut has uniform stress distribution.

The Relative Strength and Stiffness Properties Required for Strut Materials. A. G. Pugsley. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2490*, 1951, (January 1, 1947). 11 pp., illus. 6 references. British Information Services, New York. $0.75.

A Note on the Measurement of Damping in Vibrating Rods. G. G. Parfitt. *British Journal of Applied Physics*, Vol. 2, No. 11, November, 1951, pp. 327–329. 5 references. Derivation of formulas, in terms of the resonant frequency and bandwidth, for the dynamic elastic modulus and damping of thin rods vibrating longitudinally or in torsion.

Flexural Fatigue Strengths of Riveted Box Beams—Alclad 14S-T6, Alcad 75S-T6, and Various Tempers of Alclad 24S. I. D. Eaton and Marshall Holt. *U.S., N.A.C.A., Technical Note No. 2452*, November, 1951. 25 pp., illus. 11 references. Results of tests to determine and compare the flexural fatigue strengths of built-up riveted box beams; comparison with data on similar beams fabricated by spot-welding and riveting.

A General Method of Calculating the $M\epsilon_{max.}$ Diagram in Plastic Bending of Beams. Aris Phillips. *Journal of Applied Mechanics*, Vol. 18, No. 4, December, 1951, pp. 353–358, illus. 13 references.

On the Inextensional Theory of Deformation of a Right Circular Cylindrical Shell. R. M. Hermes. *Journal of Applied Mechanics*, Vol. 18, No. 4, December, 1951, pp. 341–344, illus. 7 references.

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The Instability of Thin-Walled Cylinders Subjected to Internal Pressure. J. A. Haringx. (*De Ingenieur*, Vol. 63, No. 69, July 20, 1951, pp. 0.39–0.41.) *Engineer's Digest*, Vol. 12, No. 10, October, 1951, pp. 329, 330, illus. 6 references. Derivation of a simple formula for calculating the critical internal pressure for the buckling of thin-walled cylinders; application to more complex cases; comparison with other formulas.

A Study of Elastic and Plastic Stress Concentration Factors Due to Notches and Fillets in Flat Plates. Herbert F. Hardrath and Lachlan Ohman. *U.S., N.A.C.A., Technical Note No. 2566*, December, 1951. 23 pp., illus. 12 references.

The Safety Factor of an Elastic-Plastic Body in Plane Strain. D. C. Drucker, H. J. Greenberg, and W. Prager. *Journal of Applied Mechanics*, Vol. 18, No. 4, December, 1951, pp. 371–378, illus. 14 references. Development of a method of estimating the safety factor of an elastic-plastic body under specified surface tractions.

Mathematical Principles of Rheology. H. Hencky. *Research*, Vol. 2, No. 9, September, 1949, pp. 437–443, illus. 7 references. Summary and integration of previous work on rheology, which includes all mechanical knowledge concerning strain and the flow of continuous matter.

Recent Progress in the Plastic Methods of Structural Analysis. I. II. P. S. Symonds and B. G. Neal. *Franklin Institute, Journal*, Vol. 252, Nos. 5, 6, November, December, 1951, pp. 383–407; 469–492, illus. 38 references.

Review of recent developments in methods of plastic failure analysis; definitions and illustrations of the basic hypotheses of the carrying capacity of flexural members; the basic theorems of plastic collapse under proportional loading; computations for

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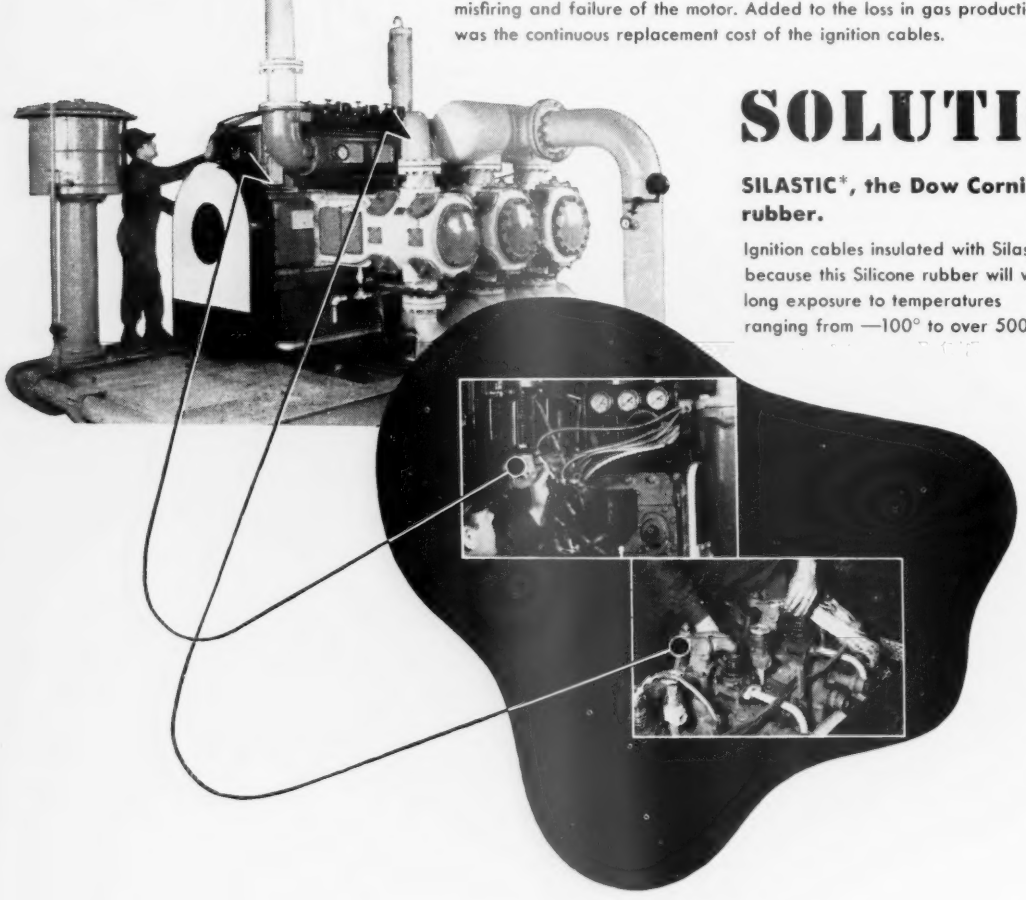

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the plastic collapse load and for fully plastic moments and their variations; techniques of computing failure loads for general continuous frames; examples of basic theorems and techniques.

The Determination of Initial Stresses by the Hole Method. Edward R. Ward. *Testing Topics*, Vol. 6, No. 3, July–September, 1951, pp. 8, 9, illus. 5 references.

A method of determining initial stresses in plates by drilling a small hole, obtaining the stresses with SR-4 strain gages, and then substituting experimental coefficients of sensitivity into two short equations that give the stress in the plate before the hole was drilled.

Vibrations of a Clamped Circular Plate Carrying Concentrated Mass. R. E. Roberson. *Journal of Applied Mechanics*, Vol. 18, No. 4, December, 1951, pp. 349–352, illus. 3 references.

Analysis of the vibrations of a clamped circular plate carrying a concentrated mass at its center; the plate is excited by a motion of the rigid framing to which it is clamped. The filtering action of the plate on the excitation forces is studied. The first four natural frequencies are found as functions of the mass ratio (concentrated mass/plate mass); an explicit expression is formulated for the motion of the mass.

Bending of Thin Ring-Sector Plates. L. I. Deverall and C. J. Thorne. *Journal of Applied Mechanics*, Vol. 18, No. 4, December, 1951, pp. 359–363, illus. 9 references.

The deflection of a thin homogeneous isotropic plate, whose plan form is a sector of a circular ring, is determined by use of the finite Fourier sine transform, for the cases in which the straight edges have arbitrary but given deflection and bending moments.

Critical Combinations of Bending, Shear, and Transverse Compressive Stresses for Buckling of Infinitely Long Flat Plates. Aldie E. Johnson, Jr., and Kenneth P. Buchert. *U.S., N.A.C.A., Technical Note No. 2536*, December, 1951. 40 pp., illus. 6 references.

Dislocations in Thin Plates. J. D. Eshelby and A. N. Stroh. *Philosophical Magazine*, Vol. 42 (7th Series), No. 335, December, 1951, pp. 1401–1405. 8 references. Comparison of the properties of a straight screw dislocation in a thin plate and in an infinite body; brief analysis of corresponding problem for an edge dislocation.

On the Stability of Plates Reinforced by Longitudinal Ribs. J. M. Klitchieff. *Journal of Applied Mechanics*, Vol. 18, No. 4, December, 1951, pp. 364–366, illus. 3 references. Analysis of the stability, based on Timoshenko's system of equations for the critical compressive force, of a plate stiffened by longitudinal ribs.

The Behavior in Compression of Aluminium Alloy Panels Having a Flat Skin with Corrugated Reinforcement. E. A. Brook. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2598*, 1951 (July, 1945). 33 pp., illus. 2 references. British Information Services, New York. $1.90.

Compression tests to evaluate the effect of rivet pitch, corrugation width, and skin and corrugation thicknesses on panels of D.T.D. 390 and D.T.D. 346 aluminum alloy. The panels, each 12 in. long, consisted of a flat skin reinforced with 3 sets of corrugations.

Stress Diffusion Adjacent to Gaps in the Inter-Spar Skin of a Stressed-Skin Wing. M. Fine and H. G. Hopkins. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2618*, (May, 1942). 13 pp., illus. 3 references. British Information Services, New York. $0.90.

Theoretical analysis of the diffusion of stress in a flat or slightly cambered symmetric wing surface near chordwise gaps in the interspar skin and stringers; such gaps occur at wing joints and at undercarriage and bomb-bay cutouts. Approximate formulas are derived for the stress distributions.

An Experimental Investigation into the Suitability of a Corrugated Construction Wing for a Laminar-Flow Aerofoil. J. C. King. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2530*, 1951 (January, 1945). 25 pp., illus., folding charts. 4 references. British Information Services, New York. $2.10.

Surface distortion tests, compression tests, proof tests to determine the loading required to produce permanent distortions that would impair the aerodynamic efficiency of the wing, and tests to determine the failure load were carried out on a 6-ft. chord wing specimen having a thick skin reinforced by spanwise corrugations. The tests were made to determine if the construction was suitable for a laminar-flow airfoil.

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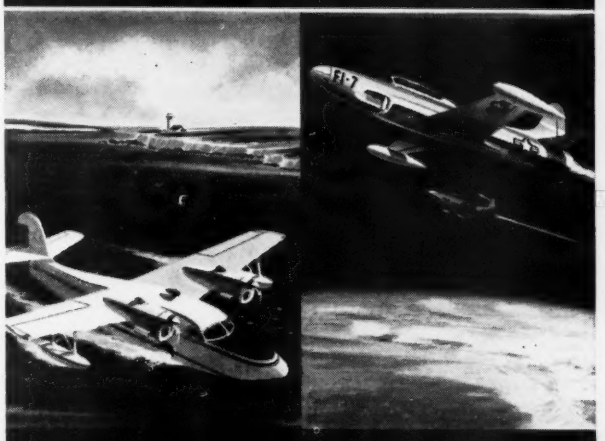

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Thermodynamics (18)

Statistical Basis of Thermodynamics. E. A. Guggenheim. *Research*, Vol. 2, No. 10, October, 1949, pp. 450–454. 6 references.

Explanation of how the laws of thermodynamics follow from a single statistical principle that assumes that the measurable properties of a closed system are obtained by averaging overall accessible independent quantum states, attaching equal weights to all such states; entropy considerations.

The Hydrodynamic Theory of Detonation. I—On the Thermochemistry and Equation of State of the Explosion Products of Condensed Explosives. G. Morris and H. Thomas. **II—On Absolute Calculations for Condensed Explosives.** Stewart Paterson. *Research*, Vol. 1, Nos. 3, 5, December, 1947, February, 1948, pp. 132–144; 221–233, illus. 55 references.

Inflammability of Gases. J. H. Burgoyne. *Research*, Vol. 2, No. 11, November, 1949, pp. 512–518, illus. 32 references. Phenomena in flame propagation which modify the concept of lower and upper limits of inflammability.

Fundamental Flame Velocities of Pure Hydrocarbons. III—Extension of Tube Method to High Flame Velocities–Acetylene-Air Mixtures. Oscar Levine and Melvin Gerstein. *U.S., N.A.C.A., Research Memorandum No. E51J05*, December 3, 1951. 21 pp., illus. 10 references.

Some Observations on Diffusion Flames at Low Pressures. F. H. Holderness. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2445*, 1951 (August, 1946). 6 pp., illus. British Information Services, New York. $0.50.

Observations on the flames from wick lamps and candles burning in a stream of air in a chamber that can be gradually evacuated; effects of scale temperature and of the chemical nature of the fuel on the pressure at which the flame is extinguished.

Variation of the Pressure Limits of Flame Propagation with Tube Diameter for Propane-Air Mixtures. Frank E. Belles and Dorothy M. Simon. *U.S., N.A.C.A., Research Memorandum No. E51J09*, December 5, 1951. 17 pp., illus. 15 references.

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Data on forced-convection heat transfer for water flowing in an electrically heated tube of circular cross section at water pressures of 200 and 2,000 lbs. per sq.in. for water velocities varying between 5 and 35 ft. per sec.

The Optimum Tube Lay-Out for Heat Exchangers. E. Eckert. (*Forschung auf dem Gebiete des Ingenieurwesens*, Vol. 16, No. 5, pp.133–140.) *Engineers' Digest*, Vol. 12, No. 11, November, 1951, pp. 358–362, illus. 4 references.

A theoretical investigation to determine the optimum tube arrangement that provides a minimum heating surface for a given pressure loss and, conversely, minimum pressure loss for a given heating surface.

The Temperature Dependence of the Thermal Conductivity of Air. W. G. Kannuluik and E. H. Carman. *Australian Journal of Scientific Research, Series A, Physical Sciences*, Vol. 4, No. 3, September, 1951, pp. 305–314, illus. 15 references.

Absolute measurements of the thermal conductivity of air at temperatures between −183° and 218°C. A quadratic formula for the temperature variation of the thermal conductivity of air is presented, and a value is suggested for the thermal conductivity of the air at 0°C. from data obtained by various hot-wire methods.

Heat Capacity Lag in Gases. Richard Walker. *U.S., N.A.C.A., Technical Note No. 2537*, November, 1951. 40 pp., illus. 89 references.

Review of the literature and main experimental programs on sonic studies of the excitation of molecular vibrations by collision; basic theory; tables for available test results; classified bibliography.

Water-Borne Aircraft (21)

How Seaplane Hulls Are Evolved from Models. *The Martin Star*, Vol. 10, No. 11, November, 1951, pp. 6, 7, illus. Facilities and methods of testing models of seaplane hulls in the Experimental Towing Tank at Stevens Institute of Technology.

Saunders-Roe Princess. *Aircraft Production*, Vol. 13, No. 158, December, 1951, pp. 373–378, illus. Procedures used in producing the main components of the Saunders-Roe Princess 140-ton flying boat.

Effects of Wing Flexibility and Variable Air Lift upon Wing Bending Moments During Landing Impacts of a Small Seaplane. Kenneth F. Merten and Edgar B. Beck. (*U.S., N.A.C.A., Technical Note No. 2063*, 1950.) *U.S., N.A.C.A., Report No. 1013*, 1951. 7 pp., illus. 2 references. Superintendent of Documents, Washington. $0.15.

Wind Tunnels & Research Facilities

The Effect of the Condensation of Atmospheric Water Vapor on Total Head and Other Measurements in the N.P.L. High-Speed Tunnels. H. H. Pearcey. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2249*, 1951 (February, 1944), pp. 1–35, illus. 18 references. British Information Services, New York. $2.25.

Investigation of total-head losses and discrepancies in the pitot traverse drag measurements, and of the disadvantages of using humid air in high-speed tunnels; explanation of losses due to condensation of water vapor and its relation to Mach Number and model size. Charts and tables show the variation in C_D with Mach Number, initial humidity, and temperature in the working section.

Note on the Interpretation of Readings of Pitot and Static Tubes in a High-Speed Tunnel in Which Condensation of Moisture is Taking Place. C. N. H. Lock. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2249*, 1951 (February, 1944), pp. 36–38, illus. 1 reference. British Information Services, New York. $2.25.

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Considerations on the Effect of Wind-Tunnel Walls on Oscillating Air Forces for Two-Dimensional Subsonic Compressible Flow. Harry L. Runyan and Charles E. Watkins. *U.S., N.A.C.A., Technical Note No. 2552*, December, 1951. 18 pp., illus. 6 references.

Bell Aircraft's Vibration Test Tower. M. Berry. *American Helicopter*, Vol. 24, No. 11, October, 1951, p. 9, illus. Test tower for subjecting aircraft parts and components weighing up to 3,000 lbs. to vibration frequencies from 1 to 15 cycles per sec.; maximum amplitude of vibration is 5 ft.

Focussing Schlieren Systems. R. W. Fish and K. Parnham. *Gt. Brit., Aeronautical Research Council, Current Papers No. 54*, 1951 (November, 1950). 17 pp., illus. 2 references. British Information Services, New York. $0.90.

Details and optical limitations of three possible grid arrangements for focussing schlieren systems that are used to measure air densities in wind tunnels; optical components; application to mirror systems.

High-Speed Wind-Tunnel Tests on Models of Two Jet-Propelled Fighters (Meteor and Vampire). Staff of the R.A.E. High Speed Wind Tunnel. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2504*, 1951 (October, 1945). 113 pp., illus. 19 references. British Information Services, New York. $6.75.

Measurements of the lift, drag, and pitching moment on models of the Meteor I single-seat fighter having two turbojet engines mounted in nacelles on the wing, and of the Vampire twin-boom single-jet fighter that has the duct entries in the leading edges of the wing roots; pressure distributions and tuft studies of two nacelle designs for the Meteor and of the downwash distribution in the tail plane region of the Vampire; measurements of the effect of tail plane height on the stability and trim of both aircraft.

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Foundations of High Speed Aerodynamics; Facsimiles of Nineteen Fundamental Studies As They were Originally Reported in the Scientific Journals. With a Bibliography Compiled by George F. Carrier. New York, Dover Publications, Inc., 1951. 286 pp., illus., diagrs., figs. Clothbound, $3.50; Paper, $1.75.

The first part of this volume is a collection of reproductions of original papers concerned with fundamental studies in the flow of compressible fluids. The second part is a bibliography of over 350 publications on the theory of compressible flow, in which the references are arranged by subject. At the end of the bibliography is a key to the abbreviations used to designate the journals. The compiler of the bibliography, George F. Carrier, is Professor of Engineering, Brown University.

Contents: On the Thermodynamic Theory of Waves of Finite Longitudinal Disturbance, W. Rankine, 1870. Über einige Bewegungen eines Gases bei Annahme eines Geschwindigkeitspotentials, P. Molenbroek, 1890. Über zweidimensionale Bewegungsvorgänge in einem Gas, das mit Überschallgeschwindigkeit strömt, T. Meyer, 1908. The Conditions Necessary for Discontinuous Motion in Gases, G. I. Taylor, 1910. On the Flow of a Compressible Fluid Past an Obstacle, Lord Rayleigh, 1916. Luftkräfte auf Flügel, die mit grösserer als Schallgeschwindigkeit bewegt werden, J. Ackeret, 1925. The Effect of Compressibility on the Lift of an Aerofoil, H. Glauert, 1928. Näherungsverfahren zur zeichnerischen Ermittlung von ebenen Strömungen mit Überschallgeschwindigkeit, L. Prandtl and A. Buseman, 1929. Aerodynamischer Auftrieb bei Überschallgeschwindigkeit, A. Buseman, 1935. The Resistance of Slender Bodies Moving with Supersonic Velocities, with Special Reference to Projectiles, T. von Kármán and N. B. Moore, 1932. Theorie des Flugzeugtragflügels im zusammendrückbaren Medium, L. Prandtl, 1936. Infinitesimale kegelige Überschallströmung, A. Buseman, 1942. Temperature Effects in a Laminar Compressible Fluid Boundary Layer Along a Flat Plate, H. W. Emmons and J. G. Brainard, 1941. L'Azione Aerodinamica sul Profilo Oscillanto in un Fluido Compressible à Velocita Iposonora, C. Possio, 1938. On an Extension of the von Kármán-Tsien Method to Two-Dimensional Subsonic Flows with Circulation Around Closed Profiles, C. C. Lin, 1946. The Interaction Between Boundary Layer and Shock Waves in Transonic Flow, H. W. Liepmann, 1946. The Hodograph Transformation in Trans-Sonic Flow, Part 3, M. J. Lighthill, 1947. Studies on Two-Dimensional Transonic Flows of a Compressible Fluid, Part 1, S. Tomotika and K. Tamada, 1950. Bibliography: (1) Hodograph Method. (2) The Rayleigh-Janzen Method. (3) The Prandtl-Glauert Method. (4) Supersonic Flow. (5) Shock Waves. (6) Boundary Layer. (7) The Oscillating Airfoil and Other Unsteady Flow Phenomena. (8) General. List of Journals.

AVIATION MEDICINE

Principles and Practice of Aviation Medicine. Harry G. Armstrong. 3rd Ed. Baltimore, The Williams & Wilkins Company, 1952. 476 pp., illus., diagrs., figs. $7.50.

Since the publication of the second edition in 1943, many things have developed in the field of aviation and consequently in the field of aviation medicine. In order to report on these developments, each chapter has been thoroughly revised, and several have been completely rewritten; four are entirely new. The subject matter has been arranged into a new grouping and sequence of topics; new figures and tables are included. The author, The Surgeon General of the U.S. Air Force, has presented information in this book which will be of value to those concerned with the civilian as well as with the military aspects of aviation medicine. References are given at the ends of chapters, and there is a 4-page subject index.

Contents: Chapter 1, Historical (To 1900). Chapter 2, Historical (Twentieth Century). Chapter 3, Principles and Practice. Chapter 4, Introduction to Pilot Selection. Chapter 5, Examination of the Eye. Chapter 6, Cardiovascular Examination. Chapter 7, Ear, Nose and Throat Examination. Chapter 8, General Physical Examination. Chapter 9, Neuropsychiatric Examination. Chapter 10, Objective Aptitude Tests for Flying Training. Chapter 11, Noxious Substances in Aviation. Chapter 12, The Atmosphere. Chapter 13, Altitude Sickness. Chapter 14, Oxygen in Aviation. Chapter 15, Aerotitis Media and Aerosinusitis. Chapter 16, Effects of Aircraft Noises. Chapter 17, Aerial Equilibration. Chapter 18, Airsickness. Chapter 19, Decompression Sickness. Chapter 20, Pressure Cabin Aircraft. Chapter 21, Speed and Acceleration. Chapter 22, Accidents in Aviation. Chapter 23, Emotional Reactions to Flight. Chapter 24, Air Rescue and Air Evacuation. Chapter 25, Aerial Hygiene and Sanitation. Chapter 26, Protective Flying Equipment.

REFERENCE WORKS

The New Military and Naval Dictionary. Edited by Frank Gaynor. New York, Philosophical Library, 1951. 295 pp., charts. $6.00.

The more than 7,000 terms and abbreviations contained in this dictionary refer to the equipment, operations, organization, personnel, and slang of the U.S. Air Force, Army, Navy, Marine Corps, Coast Guard, and civil defense services. Included are terms relating to guided missiles and rocketry, atomic energy, radioactivity, chemical and bacterial warfare, and electronics. Official glossaries and manuals were used as sources, and military authorities assisted in the compilation. Following the glossary, there are 17 pages containing charts and maps showing the organization of the U.S. Armed Forces, a table of Naval vessel and craft nomenclature, a table of comparative ranks and grades, and a list of references.

Technical Dictionary: English-Spanish, Spanish-English. T. A. Kolster. New York, Stechert-Hafner, Inc., 1951. 394 pp. $5.00.

This dictionary is the outgrowth of the author's years of experience as a translator and was published at the suggestion of persons connected with the petroleum industry in Venezuela. It contains over 25,000 geological, engineering, legal, and accounting words, terms, and expressions. Although these terms are mainly common to the petroleum industry, the dictionary should be of value in the preparation of translations in other technical fields. Some 800 abbreviations are contained in the final section of the book.

RESEARCH

Selection, Training, and Use of Personnel in Industrial Research. Proceedings of the Second Annual Conference on Industrial Research, June, 1951. Sponsored by the Department of Industrial Engineering, Columbia University. New York, King's Crown Press, 1952. 274 pp.

The objective of this conference was to assist research administrators to achieve a wider understanding and deeper comprehension of the problems involved in the selection and training of research personnel. The papers of the conference and the discussion material directly applicable to them are presented first. The discussion material from the informal clinic sessions held throughout the conference have been edited and rearranged by topic.

Contents: Welcome to Members, Robert Teviot Livingston. Opening Address, John R. Dunning. What Industry Requires of the Research Worker, Elmer W. Engstrom. The Creative Mentality and Research Problems, David B. Hertz. Selection Techniques for Research Workers, John C. Flanagan. Training of Young Researchers, H. A. Leedy. Methodology and Mathematical Statistics and Their Application in Research, Russell L. Ackoff. Industrial Research Workers and Defense, Phillip N. Powers. Research and National Manpower Policy, Ralph M. Hogan. Preliminary Report on University Research Potential, John I. Mattill. The University's Role in Training Research Workers, Harold K. Work. Coordination of Research and Development Work, John A. Leermakers. External Communication of Research Results, H. B. McClure. What Makes a Good Research Man? Sebastian B. Littauer. Clinic Session Discussions. Bibliography.

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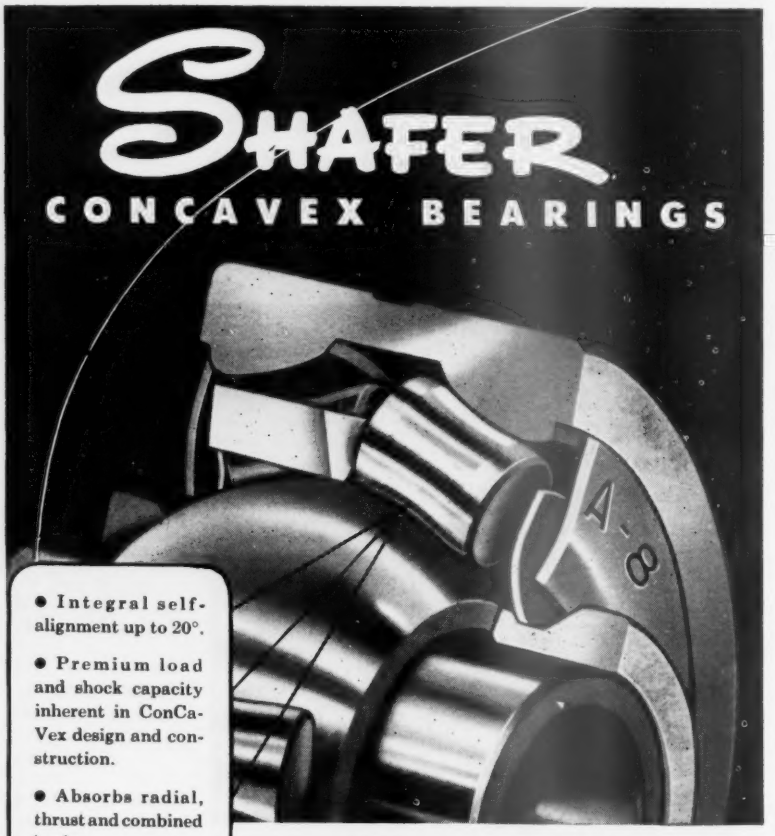

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SCIENCES, GENERAL

MATHEMATICS

Nomography and Empirical Equations. Lee H. Johnson. New York, John Wiley & Sons, Inc., 1952. 150 pp., figs., folding charts. $3.75.

The purpose of this book is to explain two useful techniques for handling such data: nomographs, which provide quick graphic answers where numerical data are substituted into formulas; and empiric equations, which are the mathematical expressions of data plotted in the form of curves. More specific discussion of each of these subjects is reserved for the introductions to Chapters 2 and 8, respectively. A working knowledge of nomographs and empiric equations is useful not only to many engineers but also to physicists, chemists, doctors, and other scientific and professional groups that engage in experimental research. Applications may be found in many phases of business and industry, such as research and development, production, sales, and management.

The treatment of nomographs is based on plane geometry and logarithms; the treatment of empirical equations requires a knowledge of logarithms and of analytic geometry. Introduced in this volume are (1) a method of analyzing an equation and its variables before plotting in nomographic form in order to determine the best arrangement of scales and (2) a discussion of the effect of scale arrangement on the accuracy of a nomograph. Problems are given at the ends of chapters. The book is concluded with a summary of empirical equations and of special cases in which ΔX is constant and with a name and subject index. Professor Johnson is Dean of the College of Engineering, Tulane University.

Contents: Part I, Nomography: (1) Introduction. (2) Parallel Scale Nomographs. (3) Z-Charts. (4) Parallel and Perpendicular Index Lines. (5) Concurrent Scales. (6) Recurrent Variables. (7) Combined Nomographs. Part II, Empirical Equations: (8) Methods of Curve Fitting. (9) Curves of Two Constants. (10) Curves of Three Constants. (11) Curves of Four Constants.

Linear Transformations in $\underline{n}$-Dimensional Vector Space. H. L. Hamburger and M. E. Grimshaw. London and New York, Cambridge University Press, 1951. 195 pp. $4.50.

The ideas and methods of the theory of linear transformations in Hilbert space are introduced by using them to present the elements of the theory in a finite dimensional vector space. The main results in the theory are developed without the use of determinants, and a concrete vector space has been chosen in preference to an abstract space so that the ideas may be more readily grasped. Only orthogonal coordinate systems are used, in order to obviate difficulties in later generalizations to Hilbert space. Analytical methods are used to obtain the spectral representations of Hermitian transformations.

Contents: Chapter 1, Linear Manifolds and Linear Transformations in $\mathfrak{B}_n$. Chapter 2, Special Linear Transformations in $\mathfrak{B}_n$. Chapter 3, Spectral Representation of Hermitian Transformations in $\mathfrak{B}_n$. Chapter 4, Spectral Properties of Linear Transformations in $\mathfrak{B}_n$. Chapter 5, Vector Spaces with Positive Hermitian Metric Forms.

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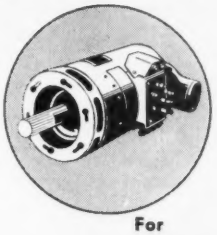

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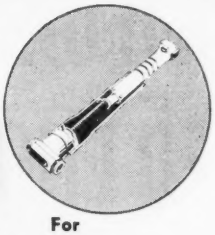

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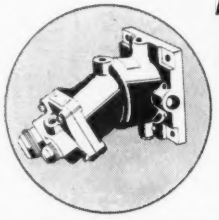

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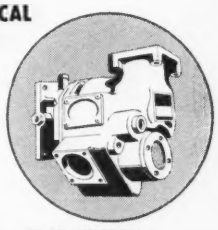

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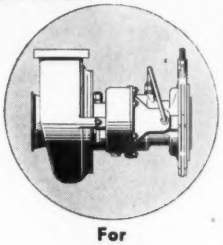

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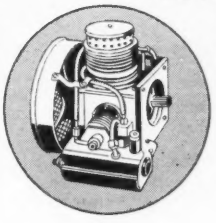

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This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

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Production Metallurgist (Physical)—Annual salary of $7,040. Position involves conducting investigations to determine suitability of metals, alloys, and metallurgical processes for use in manufacturing, repair, inspection, and maintenance of civil aircraft, and the preparation of technical information and instructions covering metallurgical processes. Bachelor degree plus 3½ years of progressive professional experience required. Lacking degree, equivalent combination of education and experience permitted. **Materials Engineer**—Annual salary of $7,040. Position involves conducting investigations to determine suitability of air-frame materials and fabrication processes for use in manufacturing and repair of civil aircraft, and the preparation of technical information and instructions covering air-frame materials and fabrication processes. Bachelor degree plus 3½ years' progressive professional experience required. Lacking degree, equivalent combination of education and experience permitted. **Structural Loads Engineer**—Annual salary of $7,040. Position involves conducting studies on air-frame structural loads in civil aircraft and the preparation of technical instructions and information covering air-frame structural loads. Bachelor degree plus 3½ years of progressive professional experience required. Lacking degree, equivalent combination of education and experience permitted. **Structural Loads Engineer**—Annual salary of $5,940. Bachelor degree plus 3 years of progressive professional experience required. Applicants should submit Standard Form 57, Application for Federal Employment (available at any Post Office) to: Personnel Office, W-91.4, Civil Aeronautics Administration, 16th & Constitution Avenue, N.W., Washington, D.C.

379. Senior Project Engineer—Wanted for work on armament, radar, aircraft, and missile systems. Good mathematics background required. Varied problems dealing with design, effectiveness, suitability, logistics, and cost. Must be capable of organizing and carrying out projects. Excellent career opportunity. Located in New Jersey, 2½ miles from New York City.

375. Engineers—Advantages of Vermont living offered by internationally known manufacturer of aeronautical equipment seeking mechanical engineers to handle production design. Plant located in small community in central section of state. Near good schools and colleges. Submit résumé and salary desired.

370. Assistant or Associate Professor—State university located in eastern United States has opening for assistant or associate professor to teach thermodynamics and design of internal combustion engines, gas turbines, etc. Salary and rank commensurate with experience and educational background.

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380. Administration Engineer—Age 29. B.S. Aero. Engr., Iowa State College; M.B.A., Production and Personnel Management major, Northwestern University. One year aircraft maintenance supervisory experience, U. S. Navy. Four years' experience with major air-frame manufacturer; 9 months design work, 8 months training program covering both engineering and production phases of the organization, 3 years flight test planning; emphasis on turbojet powerplant development work. Interested in production management work; however, will consider engineering or marketing opportunities, or work with air line contemplating jet operations. Available in June.

378. Senior Aeronautical Engineer—Ph.D. Five years' scientific work with well-known university, mainly on aerodynamic and structural subjects. Graduate and undergraduate teaching experience. More than 15 years' background with European companies in positions as aerodynamicist, flight-test engineer, designer, head of research and project groups. Presently employed as chief engineer and director of development department. Sound knowledge of modern high-speed design methods and experience in planning and leading development work. Desires position either with university as professor of aeronautical engineering in connection with research work or with prosperous aircraft firm as consultant or head of research or development group. Please advise as to the nature of openings in first letter and do not send routine forms.

377. Aeronautical Scientist—Specialist in hydrodynamics, aerodynamics, and gas dynamics. German Ph.D. Teaching experience in applied mathematics and mechanics; 12 years' experience with aircraft industry; about 50 publications and classified papers with results reported in textbooks by noted authors. Now in Government position; desires high-level research and development position or professorship combined with research. Offer with statement of salary range appreciated.

376. Aeronautical Engineer—B.S. degree from The Pennsylvania State College. Two years' experience as a trainee for a supervisory capacity with a large corporation, knowledge of shop practices and machinery and equipment repairs, plus good knowledge of transportation field—both passenger and freight. Age 25, veteran. Desires position with air line or aircraft manufacturer.

374. Aeronautical Engineer—Six years' experience in aerodynamic design of piloted airplanes and guided missiles; 3 years' experience in present supervisory position as aerodynamics engineer with Government flight-test agency. B.S. (Aero. Eng.), 1942. Presently taking evening graduate studies leading to M.S. degree in spring, 1952.

373. Project Engineer—Mechanical. Master's Degree, registered P.E. Ten years' successful record on design and development of special machinery and instruments, 3 years' supervisory experience, specialized knowledge in fields of vibration, impact, fatigue testing, and stress analysis. Analytical ability. Several publications. Desires responsible position. Specify nature of opening in first letter.

372. Engineer—B.S. in E.E., supervising inspector on assembling of Navy aircraft from raw material stage to the completely assembled product flying. Desires an opportunity to do calculation, layout, design work, etc., in evenings and week ends. (Electronic, electrical, general.) Financial reimbursements secondary. Long Island resident.

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369. Aeronautical Engineer—Unusual background of practical experience in the production of precision products, welded products, and aircraft fabrication. Excellent background in the design and development of aircraft and aircraft-type structures in both aluminum and magnesium alloys. Well versed in production planning, processing, tooling, and quality control. Excellent supervisory record in the foregoing in both the aircraft and automotive industries. Desires responsible position as production manager, superintendent, master mechanic, or similar capacity in the aircraft or allied industry. West Coast location preferred.

368. Aeronautical Engineer—B.S., M.S.Ae.E. Eight and one-half years in aviation includes 3½ years' experience in research, development, and testing of guided missiles, 2 years in supervisory position. Thoroughly familiar with supersonic wind-tunnel testing procedures. Holds A&E license since 1944. Seeks good supervisory position with good possibility for advancement. Outline of work programs desirable for proper consideration.

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352. Aeronautical Engineering Professor-Development Engineer (M.S.)—Extensive and varied aeronautical background (both administrative and technical) in fixed and rotating wing aircraft. Graduate and undergraduate teaching experience in aerodynamics (classical and supersonic), design, and structures. Many aeronautical publications, including textbook. Will consider research and administrative possibilities.

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